ROCK CREEK / MUDDY CREEK RESERVOIR

Draft
Environmental Impact Statement

United States Forest Service
Rocky Mountain Region
Lakewood, Colorado

United States
Department of
Agriculture

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DRAFT ENVIRONMENTAL IMPACT STATEMENT

FOR THE ROCK CREEK/MUDDY CREEK RESERVOIR

ROUTT AND GRAND COUNTIES, COLORADO

Lead Agency: USDA-Forest Service

Cooperating Agencies: USDI-Bureau of Land Management
USDI-Fish and Wildlife Service
USDI-Bureau of Reclamation
U.S. Army Corps of Engineers
Colorado Division of Wildlife

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Abstract: This draft environmental impact statement documents the analysis of the construction of two proposed water storage reservoirs in western Colorado. The alternatives are: Rock Creek Reservoir (the Applicant's proposed action) in the Routt National Forest and Muddy Creek Reservoir in the Bureau of Land Management Kremmling Resource Area. The no-action alternative assumes that a permit for construction of a dam and reservoir would not be issued for either the Rock Creek site (U.S. Forest Service) or the Muddy Creek site (Bureau of Land Management). The Forest Service does not have a preferred alternative. Both the Rock Creek and Muddy Creek alternatives are described and analyzed in detail, and mitigation approaches are proposed for both sites. Following review of public comments on this draft document, the Forest Service and the Bureau of Land Management will make the determination of whether Rock Creek, Muddy Creek, or the no-action alternative best serves the public interest. The environmentally preferred alternative is the no-action alternative.

Comments must be received by OCT 26 1987.

SUMMARY
ROCK CREEK/MUDDY CREEK RESERVOIR
ENVIRONMENTAL IMPACT STATEMENT

Background and Purpose of the Project

Purpose and Need for Project

An environmental analysis and alternatives evaluation was undertaken in response to an application submitted to the Forest Service on April 3, 1985, by the Colorado River Water Conservation District (River District) for a Special Use Permit for the construction of a water storage reservoir on Rock Creek in the Yampa Ranger District, Routt National Forest. An alternative dam and reservoir on Muddy Creek (Site C) in the Bureau of Land Management Kremmling Resource Area was also evaluated as a possible construction site.

In reviewing the River District's Special Use Permit Application, the Forest Service determined that the proposed construction may involve significant environmental impacts. In accordance with the National Environmental Policy Act (NEPA), the Forest Service has conducted environmental and socioeconomic analyses of the effects of the proposed project and reasonable alternatives. This Summary reviews briefly the purpose of the project, describes the two alternatives, highlights impacts disclosed, and identifies measures to mitigate these impacts.

The River District proposes to utilize Rock Creek Reservoir (or an alternative site) in a manner that meets both Metropolitan Denver and West Slope water demands pursuant to the statutory mandate of the District. The proposed interim operation of the project involves the lease of a major portion of the reservoir yield to the Denver Water Board for 25 years to be used by Denver to meet water needs in the Denver metropolitan area. Following this 25-year period, Denver could renew the lease for any portion of the firm annual yield that the River District determines is not necessary for western Colorado use. This lease could provide the District with the means to finance a portion of this project and to pursue its statutory obligations in support of present and future water needs in western Colorado. During the period of the lease the District would retain 10 percent of the yield of the project to support or service water users in western Colorado.

History of the Proposed Project

The River District's application to the Forest Service for a special use permit to build a water storage reservoir is the result of an extremely complex and lengthy series of legal actions and negotiations involving the adjudication, permitting and construction of the Windy Gap Project. This series of actions and negotiations provides the financial basis for the River District to undertake construction of the proposed project or an alternative. The Azure-Windy Gap Supplemental Agreement of March 1985 resulted in a cash payment of $10,200,000 from the Northern Colorado

Conservancy District's Municipal Subdistrict to the River District to permit, design, and construct a water storage reservoir in western Colorado as mitigation for the Windy Gap project. The River District-Denver Water Board agreement of December 15, 1986, would provide the River District with additional funds to meet its statutory purposes, including construction of the proposed project (or an alternative reservoir).

Related Projects

Windy Gap and Green Mountain. A number of different water projects would be related to or impacted by the operation of the proposed project. As described earlier, the proposed project is part of the mitigation package related to the Windy Gap Project.

The proposed reservoir also would be operated in conjunction with the Bureau of Reclamation's Green Mountain Reservoir. An environmental statement covering the marketing of Green Mountain Reservoir water has been prepared by the Bureau of Reclamation and the River District. The draft environmental statement was published September 6, 1985. The final statement is ready for filing once the U. S. Fish and Wildlife Service issues a biological opinion on the project.

Metropolitan Denver Water Supply Systemwide DEIS. The U. S. Army Corps of Engineers has prepared the Metropolitan Denver Water Supply Draft EIS (MDWS/DEIS) disclosing the impacts of the development of additional water sources needed to supply water for future growth to the metropolitan Denver area (including all or parts of Adams, Arapahoe, Boulder, Denver, Douglas, Jefferson, and Weld counties). The MDWS/DEIS describes both system-wide and site-specific alternatives to supply this water. West Slope Exchanges are included in the various system-wide alternatives to meet metropolitan Denver's near-term water needs. The MDWS/PEIS identifies both the proposed Rock Creek and Muddy Creek (Wolford Mountain) reservoirs as components in a Blue River Exchange Scenario. Demand for the entire area is projected to exceed the developed safe yield in about 1989. By the year 2035, the demand is projected to exceed the current safe yield supply capability by about 288,000 acre-feet per year.

Under the Denver Water Board - River District agreement of December 1986, the District would lease a major portion of the yield of the Rock Creek or Muddy Creek reservoir to the Denver Water Board for a 25-year period. The Water Board could use either reservoir in support of exchanges to accomplish transmountain diversions by making releases which would permit an equivalent amount of water to be either retained in reservoirs owned by Denver or diverted under direct flow decrees owned by Denver.

Joint-Use Reservoir and Green Mountain Exchange Projects. At the request of the River District and the Denver Water Board, the Colorado Water Resources and Power Development Authority is conducting a study of the Joint-Use Reservoir and Green Mountain Exchange projects. The study

will provide reconnaissance level engineering and hydrology information on these projects.

The upper Colorado River system was examined by the Colorado Water Resources and Power Development Authority for candidate sites. Unregulated streams (Muddy Creek, Troublesome Creek, and the Piney River) were considered along with previously studied reservoir sites. Nine sites were identified during the development of a plan of study, among them sites A and C on Muddy Creek (Wolford Mountain). Site A (or A') would be a large 120,000 acre-foot reservoir on Muddy Creek near Kremmling. Site C of the Authority study coincides with Site C on Muddy Creek as evaluated here.

Grand County Commissioners' Position

The Board of Commissioners of Grand County and the Middle Park Water Conservancy District have indicated their support for a reservoir on Rock Creek. In exchange, the River District will support the future development of a large reservoir on Muddy Creek, if technically and economically feasible, and work toward developing structural and/or nonstructural solutions to water problems in the Upper Fraser Valley.

Scope of Public Issues and Management Concerns Identified and Addressed

As a result of scoping, internal staff review, and consultation with cooperating agencies, the Forest Service determined that major issues and management concerns for the Rock Creek site and reasonable alternative sites could be grouped into the following categories. A generalized listing of the major issues which could have a significant influence on site selection is also included below.

Water - Stream channel stability, morphology, and equilibrium

- Chemical and physical water quality conditions during and after construction

- Salinity effects in Lower Colorado River main stem

Engineering - Dam safety, flood risk, hazard rating, and seismic activity

- Facilities relocation

- Post-project traffic patterns

- Location, development, and reclamation of materials borrow sources

Soils - Compatability of soils with projected uses

- Reservoir shoreline stability

Wildlife/ Vegetation	-	Wildlife values, disturbance of winter/summer range and habitat, migration, and/or distribution patterns of elk and deer
	-	Impact and loss of wetland, riparian habitat, and threatened and endangered plants
Fishery	-	Impact on or loss of stream habitat and characteristics of reservoir habitat
	-	Projected fishing use of affected area
Recreation/ Social	-	Effect of reservoir operations on recreation use
	-	Recreation potential and projected use
	-	Land use changes and impacts on private lands
	-	Visual impacts
	-	Cultural resources
Economic	-	Efficiency and impact of alternative reservoirs

Description of Rock Creek and Muddy Creek Alternatives

Alternatives Considered but Eliminated from Detailed Study

To determine alternatives that would be reasonable and feasible considering the history of the proposed project, a set of criteria were established. First, the alternative should provide approximately the same water yield as anticipated with the Azure Project (about 20,000 acre-feet). Second, the total project cost and cost per acre-foot of water yield should be reasonable in relation to the Azure-Windy Gap Supplemental Agreement. Finally, the project should be located within reasonable proximity of Windy Gap, the project being mitigated. Using these criteria a number of alternative sites and enlargements of existing reservoirs were considered. Other than the Rock Creek site in Routt County, the only reasonable alternative is on Muddy Creek in Grand County.

No-Action Alternative

As required, a no-action alternative is considered. The no-action alternative assumes that a permit for construction of a dam and reservoir would not be issued for any site on either Rock Creek (U. S. Forest Service) or Muddy Creek (Bureau of Land Management). The no-action alternative provides a baseline for analysis of impacts. Under the no-action conditions the River District would be required to initiate a variety of legal and institutional proceedings related to the adjudication and negotiations described above.

Construction Alternatives - Rock Creek and Muddy Creek

The Rock Creek site is the applicant's proposed action and is located just south of State Highway 134 west of Gore Pass, where Rock Creek enters a narrow valley. The Rock Creek Dam is proposed to be a roller compacted concrete (RCC) gravity dam, that would rise 172 feet above the existing streambed and impound 50,700 acre-feet of water. The Muddy Creek alternative was sized to be functionally equivalent to a Rock Creek project, with the site located just west of Wolford Mountain, (5 miles north of Kremmling, Colorado). The Muddy Creek Dam is proposed to be a zoned earthfill dam that would have a dam crest located 110 feet above the present streambed and would create a reservoir with a 46,800 acre-foot capacity.

The following table provides a summary comparison of the physical features of the Rock Creek and Muddy Creek construction alternatives.

Comparison of Physical Features
Rock Creek and Muddy Creek Alternatives

Project features	Unit	Rock Creek	Muddy Creek
Reservoir			
Capacity	ac-ft	50,700	46,800
Conservation storage	ac-ft	4,000	4,000
Sediment storage	ac-ft	500	6,000
Yield	ac-ft/yr	17,000	17,000
Surface area	acres	1,070	1,200
Length	miles	3	5
Dam			
Type	-	Roller compacted concrete	Zoned earth fill
Crest elevation	feet	8,690	7,490
Height	feet	172	110
Volume	1000 yd^3	180	680
Crest length	feet	707	1,895
Crest width	feet	16	20
Outlet type	-	Single	Multiple
Discharge at min. reservoir	cfs	300	400

Environmental Impacts and Mitigation Summary

The most significant adverse environmental impacts of the Rock Creek and Muddy Creek construction alternatives are summarized by discipline in the following table. Mitigation requirements for adverse environmental impacts are also summarized.

Rock Creek Impacts and Mitigation Summary

Adverse Impacts	Mitigation
Soils	
18% of shoreline unsuitable for recreation.	No mitigation proposed.
Erosion of disturbed soils	Erosion control plan.
Surface Water	
Channel stability concerns.	Channel maintenance flow utilized in dam release schedule.
Risk of dam failure.	Inspection, monitoring, and emergency plan will be developed.
Water Quality	
None	
Air Quality	
Short-term construction impacts.	Use of filters and dust control techniques.
Vegetation	
486 acres of high quality wetland lost.	Wetland values replaced in kind by purchasing and upgrading of Egeria Creek and wetlands.
Aquatic Biology	
Loss of 9 miles of high quality trout stream.	Rehabilitate offsite (Egeria Creek) but some values lost.
Loss of self-sustaining trout population below dam.	Monitor and stock to maintain fishable resource.
Wildlife	
Loss of wetland wildlife values.	Replace lost habitat units by purchase and development of nearby wetlands and stream.
Disturbance and loss of habitat.	Restrictions on vehicular use off road.
Elk may break through reservoir ice.	Monitor and fence if necessary.
Land Use Plans	
Amendment to Forest Plan required.	Amend Forest Plan.
Inundation of 1070 acres existing land use.	Compensate private landowner.

Rock Creek Impacts and Mitigation Summary
(continued)

Adverse Impacts	Mitigation
Grazing	
11% loss of forage to one cattle allotment.	Purchase of private land near reservoir.
Visual Resources	
Dam and reservoir would require VQO amendment.	Forest Plan would be modified but some VQO exceedance would remain.
Recreation	
Loss of stream fishery and associated recreation.	Public access to upgraded stream in wetland would mitigate most of loss.
Cultural Resources	
High potential for loss of important sites.	Survey area and mitigate important sites.
Loss of Stage Stop.	Move Stage Stop to adjacent area or catalogue and inundate.
Social	
Potential conflict between supporters and non-supporters of dam.	No mitigation practical.
Loss of rural characteristics.	No mitigation practical.
Economic	
No significant adverse impacts for two-county region.	No mitigation required.
Transportation	
Short-term increase in traffic and delays.	Institute traffic control measures.
Soils	
49% of shoreline unsuitable for recreation.	No mitigation proposed.
Erosion of disturbed soils.	Erosion control plan.
Loss of 744 acres farmland.	Purchase to mitigate economic loss.
Surface Water	
Risk of dam failure.	Inspection, monitoring, and emergency plan will be developed.
Water Quality	
Potential eutrophication and turbidity concerns in reservoir.	Reservoir will be monitored and modeled during design phase and early years of operation.

Muddy Creek Impacts and Mitigation Summary

Adverse Impacts	Mitigation
Air Quality	
Short term construction impacts.	Use of filters and dust control techniques.
Vegetation	
207 acres of native wetland and 450 acres of man-affected wetland lost.	Wetland values replaced in kind by purchasing and upgrading nearby wetlands on lower Muddy Creek and adjacent to reservoir.
Potential loss of candidate endangered plant.	Determine extent of impact and mitigate but a portion of loss may remain.
Aquatic Biology	
No adverse impacts.	No mitigation required.
Wildlife	
Loss of wetland wildlife values.	Replace lost habitat units by purchase and development of nearby wetlands and management of public lands.
Loss of 1300 acres big game winter range.	Enhance carrying capacity of known winter range.
Losses from auto collisons and breaking through reservoir ice.	Highway warning signs, monitor and fence if necessary.
Land Use Plans	
Amendment to Resource Management Plan required.	Amend Resource Management Plan
Inundation of 1200 acres of existing land use.	Compensate private landowners.
Grazing	
Loss of 2043 AUMs on private land.	Purchase of private land would include forage value.
Visual Resources	
Dam access road and material site would create visual concern.	Revegetate cut slope and material site to blend into area.
Reservoir would exceed VRM.	Amend Resource Management Plan.
Cultural Resources	
High potential for loss of important sites.	Survey area and mitigate important sites.

Muddy Creek Impacts and Mitigation Summary
(continued)

Adverse Impacts	Mitigation
Social	
Loss of ranching operations.	Compensate landowners.
Loss of rural characteristics.	No mitigation practical.
Economic	
No significant adverse impacts for two-county region.	No mitigation required.
Transportation	
Short-term increases in traffic and delays.	Institute traffic control measures.

The Preferred Alternative

The U.S. Forest Service does not have a preferred alternative. Both the Rock Creek and Muddy Creek alternatives are described and analyzed in detail, and mitigation approaches are proposed for both sites. The alternatives considered are similar in terms of costs, operations, and yields. The differences between the alternatives relate to socio-economic effects, environmental impacts, and the projected effectiveness of mitigating these impacts. The Forest Service is actively soliciting the views of the public, State and local governments and agencies, and other Federal agencies on what weight to place on the various effects or impacts of the two alternatives. This public input will be used by the Forest Service and the Bureau of Land Management in making the determination of whether Rock Creek, Muddy Creek, or the no-action alternative best serves the public interest.

The decision will be documented in a Record of Decision signed by the Regional Forester, Rocky Mountain Region, USDA Forest Service and/or the Colorado State Director, USDI Bureau of Land Management. This document has been written to satisfy NEPA compliance requirements for either a Rock Creek site or a Muddy Creek site.

The Environmentally Preferred Alternative

The environmentally preferred alternative is the no-action alternative.

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1.0. PURPOSE AND NEED FOR ACTION

1.1. Introduction

An Environmental Impact Statement (EIS) is a document disclosing the environmental consequences of implementing a proposed action and alternatives to that action. It is not a decision document. The decision will be documented in a Record of Decision signed by the Regional Forester, Rocky Mountain Region, USDA Forest Service and/or the Colorado State Director, USDI Bureau of Land Management.

Environmental consequences on lands and activities administered by other Federal, State, and local jurisdictions resulting from the proposed action and alternatives are disclosed in this EIS. As Cooperating Agencies, other Federal and State jurisdictions have assisted in the disclosure of environmental consequences and development of alternatives to the proposed action.

The Forest Service decision will relate only to National Forest System lands and the Bureau of Land Management decision will relate only to Public Land. These decisions will be documented in a Record of Decision. Decisions by other jurisdictions to issue or not issue approvals related to this proposal may be aided by the disclosure of impacts available in this document. The U. S. Forest Service is the lead agency for this environmental compliance action. Cooperating agencies include: USDI Bureau of Land Management, USDI Bureau of Reclamation, U.S. Army Corps of Engineers, USDI Fish and Wildlife Service, and Colorado Division of Wildlife. The approvals needed by the proponent from other jurisdictions are listed in Section 1.8.

Section 1.2 outlines the purpose and need for the action. Section 1.3 reviews the history of the proposed project and Section 1.4 reviews the purpose of the proposed project. Section 1.5 reviews the relationship between the proposed project and other existing and proposed projects within the region. Section 1.6 summarizes the scope of the environmental issues to be addressed. Section 1.7 summarizes the Federal land use plans applicable to the proposed project, and Section 1.8 lists other Federal, State, and local permits necessary for the project.

1.2. Purpose and Need for Action

The environmental analysis documented in this EIS was undertaken in response to an application submitted to the Forest Service on April 3, 1985, by the Colorado River Water Conservation District (River District) for a Special Use Permit for the construction of a water storage reservoir on Rock Creek, located on National Forest System land within the Yampa Ranger District, Routt National Forest (Applicant's proposed action).

In reviewing the River District's Special Use Permit Application, the Forest Service determined that the proposed construction may involve significant environmental impacts. In accordance with the National Environmental Policy Act (NEPA), Council on Environmental Quality regulations (40

CFR Part 1500), Forest Service Manual 1950, Forest Service Handbook 1909.15, and other Federal laws and regulations, the Forest Service has conducted environmental and socioeconomic analyses of the effects of the proposed project and reasonable alternatives. This EIS documents these analyses, discloses the effects of the proposed project and alternatives, and identifies measures to mitigate these effects.

The River District, a political subdivision of the State of Colorado, was organized in 1937 under CRS 37-46-101, et seq., and is based in Glenwood Springs, Colorado. In forming the River District, the Colorado General Assembly declared that conservation of the water of the Colorado River in Colorado for storage, irrigation, mining, and manufacturing purposes and the construction of reservoirs, ditches, and works for the purpose of irrigation and reclamation of additional lands not yet irrigated, as well as to furnish a supplemental supply of water for lands now under irrigation, was of vital importance to the growth and development of the entire district. Also, that the District is the appropriate agency for the conservation, use, and development of the water resources of the Colorado River and its principal tributaries and should have such powers as may be necessary to safeguard for Colorado all waters to which the State of Colorado is equitably entitled under the Colorado River compact. The District includes 12 counties and portions of 3 others which encompass the Upper Colorado River watershed in Colorado. Each county has representation on the District's Board of Directors.

Among the District's general powers are the powers to make surveys and conduct investigations to determine the best manner of utilizing streamflows within the District, the amount of such streamflow or other water supply, and to locate ditches, irrigation works, and reservoirs to store or utilize water for irrigation, mining, manufacturing, or other purposes. Also, to make filings upon such water and initiate appropriations for the use and benefit of the ultimate appropriators, and to perform all acts and things necessary or advisable to secure and insure an adequate supply of water, present and future, for irrigation, mining, manufacturing, and domestic purposes within the District.

The River District proposes to utilize Rock Creek Reservoir (or an alternative site) in a manner that meets both Metropolitan Denver and West Slope water demands pursuant to the statutory mandate of the District. The proposed interim operation of the project involves the lease of a major portion of the reservoir yield to the Denver Water Board for 25 years to be used by Denver to meet water needs in the Denver metropolitan area. Following this 25-year period, Denver could renew the lease for any portion of the firm annual yield that the River District determines is not necessary for western Colorado use. This lease could provide the District with the means to finance a portion of this project and to pursue its statutory obligations under CRS 37-46-101, et. seq., in support of present and future water needs in western Colorado. During the period of the lease the District would retain 10 percent of the yield of the project to support or service water users in western Colorado.

As discussed in Section 1.5.2, the proposed reservoir would be utilized to meet the near-term water needs of the metropolitan Denver area, and is included in the Metropolitan Denver Water Supply Draft Environmental Impact Statement (MDWS/DEIS). Chapter 2 - Purpose and Need, of the MDWS/DEIS establishes the safe annual yield of existing water supplies and project water demands for the metropolitan Denver area to the year 2035. As stated in Chapter 2 of the MDWS/DEIS:

> Demand for the entire area is projected to exceed the developed safe yield in about 1989. By the year 2035, the demand is projected to exceed the current safe yield supply capability by about 288,000 acre-feet per year.

The analysis upon which these projections are based is presented in MDWS/DEIS Technical Appendix 2 - Future Water Demands. Chapter 2 of the MDWS/DEIS and Technical Appendix 2 are specifically incorporated into this document by reference as provided for by 40 CFR 1502.21. The MDWS/DEIS and appendices are available from the Omaha District, U. S. Army Corps of Engineers, 1612 U. S. Post Office and Customhouse, Omaha, Nebraska 68102-4978, and may be reviewed at the Forest Supervisor's Office, Routt National Forest, 29887 West U. S. 40, Suite 20, Steamboat Springs, Colorado.

The operations of the proposed reservoir are more fully described in Chapters 2 and 4. Potential environmental impacts as well as secondary and cumulative impacts of the proposed action are discussed in Chapter 4. Proposed mitigation measures are outlined in Chapter 5.

1.3. History of the Proposed Project

The River District's application to the Forest Service for a special use permit to build a water storage reservoir is the result of an extremely complex and lengthy series of legal actions and negotiations involving the adjudication, permitting and construction of the Windy Gap Project. This series of actions and negotiations provides the financial basis for the River District to undertake construction of the proposed project or an alternative. The Azure-Windy Gap Supplemental Agreement of March 1985 resulted in a cash payment of $10,200,000 from the Northern Colorado Conservancy District's Municipal Subdistrict to the River District to permit, design, and construct a water storage reservoir in western Colorado as mitigation for the Windy Gap project (see Section 1.3.5). The River District-Denver Water Board agreement of December 15, 1986, would provide the River District with additional funds to meet its statutory purposes, including construction of the proposed project (or an alternative reservoir) (see Section 1.3.6).

1.3.1. Adjudication of Windy Gap Project.

The Windy Gap Project is a transmountain water diversion project which commenced operation in 1985 and which is owned and operated by the Northern Colorado Water Conservancy District Municipal Subdistrict (Fig. 1.3.1). Windy Gap diverts water from the Colorado and Fraser rivers in Grand County to five northeastern Colorado cities: Estes Park, Boulder, Loveland, Longmont, and Greeley, and the

Platte River Power Authority. Windy Gap water is delivered through the Continental Divide using the physical facilities of the U. S. Bureau of Reclamation's Colorado-Big Thompson Project (C-BT).

Under Colorado water law, the right to divert and use surface water is adjudicated in the state courts. In 1968, the cities of Boulder, Longmont, Estes Park, Loveland, Fort Collins, and Greeley applied to the District Court for water rights on the Windy Gap Project. This application was opposed by the River District and western Colorado entities including the Middle Park Water Conservancy District.

In 1970, the same cities that made the application for the Windy Gap water rights formed the Northern Colorado Water Conservancy District's Municipal Subdistrict (Municipal Subdistrict). The water rights application for the Windy Gap project was assigned and deeded to the Municipal Subdistrict upon its creation.

After lengthy hearings, the District Court for Water Division 5 granted a conditional water decree for the Windy Gap project. This decision was appealed to the Colorado Supreme Court. On September 14, 1979, the Colorado Supreme Court overturned the District Court's decision in Colorado River Water Conservation District v. Municipal Subdistrict, 198 Colo. 352, 610 P.2d 81 (1979).

The Colorado Supreme Court ruled that a conditional water right for the Windy Gap project could not be granted until the Municipal Subdistrict had defined a plan to adequately mitigate the potential harm to present and prospective water users within the Colorado River drainage basin in Colorado. This requirement for mitigation is specified in Section 37-45-118 (1) (b) (IV), C.R.S. 1973. The matter was remanded to the District Court for further deliberation contingent upon compliance by the Municipal Subdistrict with the above statute. The parties involved in the case then entered into a series of negotiations to resolve the issues without further litigation.

1.3.2. Azure-Windy Gap Settlement of April 30, 1980. From September 1979 through April 1980, the River District and other western Colorado organizations negotiated with the Municipal Subdistrict for a settlement to satisfy the requirements of the Supreme Court ruling. The western Colorado parties other than the River District were:

1. Middle Park Water Conservancy District (Middle Park)--a water conservancy district encompassing Grand and Summit counties. Middle Park was involved in the settlement because it holds water rights that are impacted by the Windy Gap project and provides water to municipalities and other water users in the vicinity of the Windy Gap project.

2. Grand County Board of County Commissioners (Grand County)--involved in the negotiations because the Windy Gap project was located within the boundaries of Grand County and its construction requires the issuance of a county land use permit.

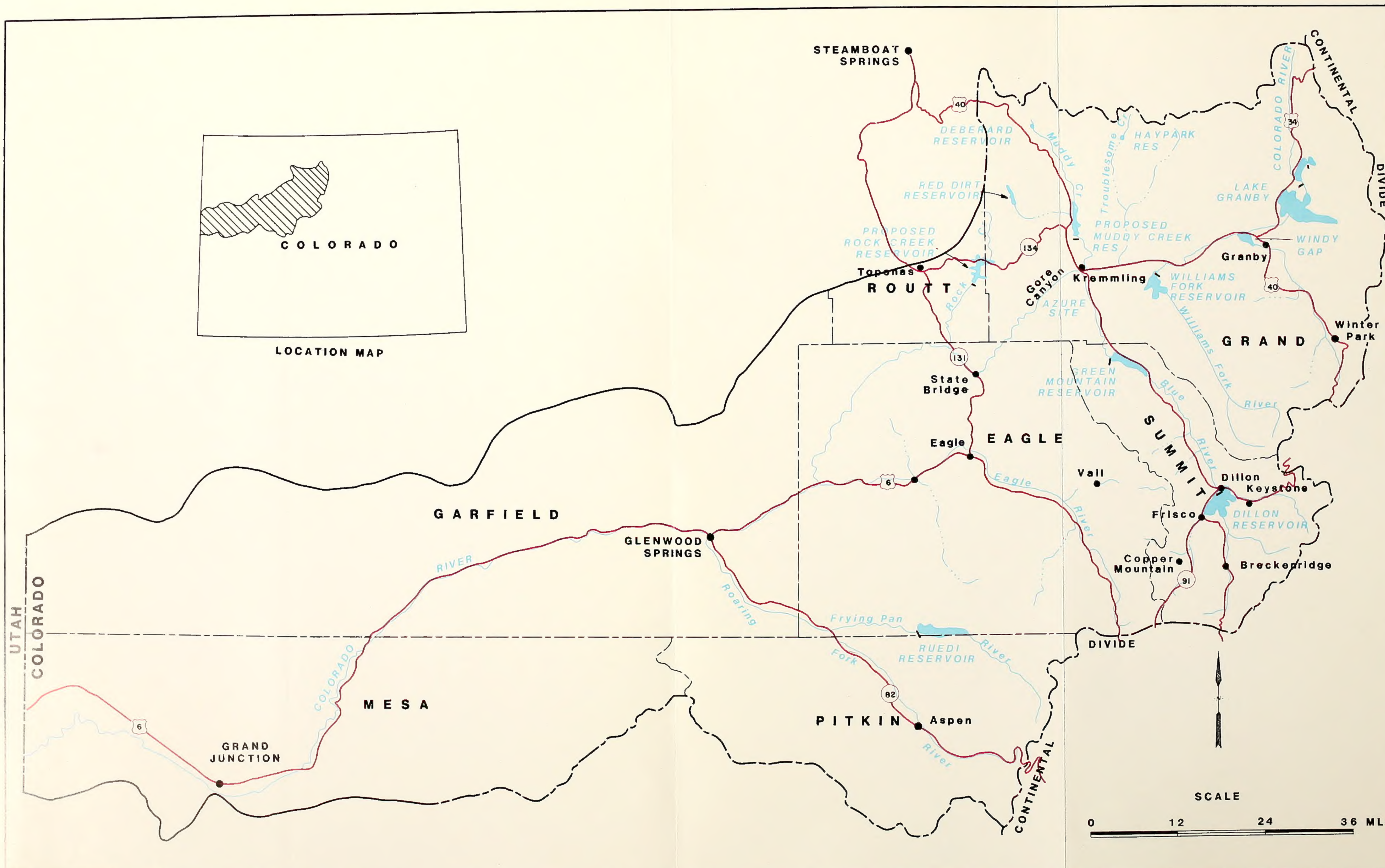

Figure 1.3.1 - Location Map for the Proposed Rock Creek and Muddy Creek Reservoir Sites.

3. Northwest Colorado Council of Governments (NWCCOG)--involved in the negotiations because some of its constituent towns and counties would be impacted by the construction and operation of the Windy Gap project.

These negotiations resulted in a settlement that was signed on April 30, 1980, and approved by the District Court on October 27, 1980.

Under the April 30, 1980, agreement, the Municipal Subdistrict agreed to provide a number of site-specific mitigation actions including such things as upgrading the diversion headgates of ranchers that would be impacted by reduced flows and upgrading the sewage treatment plant for the Town of Hot Sulphur Springs.

The agreement also called for the Municipal Subdistrict to design, construct, and operate Azure Reservoir on the main-stem Colorado River (Fig. 1.3.1) for the benefit of the economy of the West Slope. Azure Reservoir is further described in Chapter 2. As anticipated by the agreement, Azure Reservoir would have had a capacity of approximately 28,000 acre-feet and a water yield of approximately 20,000 acre-feet per year. Of this 20,000 acre-feet yield, 2,000 acre-feet would have been provided to Middle Park.

Under the agreement, the western Colorado entities agreed to withdraw their opposition in court to the Municipal Subdistrict's application for a water right on the Windy Gap Project and agreed to support the issuance of the Federal, State, and local permits necessary for the construction of the Windy Gap Project.

1.3.3. Construction of the Windy Gap Project. Prior to construction of Windy Gap, the Municipal Subdistrict had to obtain a number of Federal actions, which were: (1) execution of a water carriage contract between the Bureau of Reclamation and the Municipal Subdistrict for use of the Bureau's Colorado-Big Thompson (C-BT) Project facilities, (2) issuance of permits and/or easements by the Bureau of Land Management and the Forest Service allowing a pipeline (Windy Gap to Lake Granby) to be constructed by the Municipal Subdistrict on lands administered by the Federal Government, and (3) issuance of a Section 404 dredge and fill permit by the Corps of Engineers.

These Federal actions required the preparation of draft and final environmental impact statements. The Windy Gap Project draft EIS (INT-DES-79-33) was completed on June 18, 1979. The final EIS (INT-FES-81-20) was completed on April 28, 1981. The April 30, 1980, Agreement was an appendix of the final EIS.

Construction on the Windy Gap Project commenced in July 1981 and was completed in June 1985. The project is now in operation.

1.3.4. Evaluation of the Azure Project. From 1981 through 1983, the Municipal Subdistrict conducted numerous engineering and environmental studies on the Azure Project. These studies eventually led to the preparation of a Major Hydroelectric Project License Application to the Federal Energy Regulatory Commission (FERC) filed in December 1983. The hydroelectric project proposed by the Municipal Subdistrict in the FERC license application included a pumped storage component sized at approximately 800 megawatts. The amount of water storage available to western Colorado was limited to 15,000 acre-feet. The Municipal Subdistrict included pumped storage as a component of the project to improve the project's economic feasibility.

The River District and other western Colorado governmental entities strongly objected to the Municipal Subdistrict's plans for including pumped storage as a component of the Azure Project. Further investigations by the Municipal Subdistrict and the River District revealed that the Azure Project should not be pursued. Reasons for not pursuing the Azure Project include the following:

1. The high cost of the Azure dam and reservoir. A 23,000 acre-foot reservoir was estimated to cost approximately $30,000,000 (this figure did not include any power components).

2. Objections to the Azure Project by local entities, including the Grand County Board of County Commissioners. These objections included concerns over the Azure Project's impacts on the rafting industry in Gore Canyon.

3. An unresolved dispute between the River District and the Municipal Subdistrict over the size of the proposed Azure Reservoir. The April 30, 1980, Agreement anticipated the construction of a dike to protect the Denver and Rio Grande Railroad and provide 28,000 to 30,000 acre-feet of storage capacity. The Municipal Subdistrict took the position that the construction of this protective dike was technically not feasible at a reasonable cost. The River District did not agree with this position. Without the construction of this protective dike, the capacity of the reservoir was limited to approximately 23,000 acre-feet.

1.3.5. Azure-Windy Gap Supplemental Agreement of March 29, 1985. After it became apparent that there were serious problems facing the construction of Azure Reservoir and that there was a possibility of further litigation, the River District, Middle Park, NWCCOG, Grand County, and the Municipal Subdistrict entered a series of negotiations to amend the April 30, 1980, Azure-Windy Gap Agreement. To support the negotiations, the River District and the Municipal Subdistrict investigated a number of alternatives to the proposed reservoir at Azure. These alternatives are described further in Chapter 2.

The River District and Municipal Subdistrict determined that there were alternative water storage reservoirs that could be constructed at a

much lower cost than the proposed Azure Reservoir and still provide approximately the same water yield. These alternatives include reservoirs on Rock Creek and Muddy Creek which are described in detail in Chapter 2.

The negotiations resulted in the Azure-Windy Gap Supplemental Agreement of March 29, 1985. The supplemental agreement amended only the portions of the April 30, 1980, agreement dealing with the construction and operation of Azure Reservoir. Under the supplemental agreement, the Municipal Subdistrict provided the River District with a cash payment of $10,200,000. The River District assumed the responsibility for the permitting, design, and construction of a water storage reservoir as an alternative to Azure. The District Water Court reviewed and approved the supplemental agreement on August 26, 1985.

In April 1985 the River District submitted the application for a Special Use Permit to the Forest Service for construction of Rock Creek dam and reservoir. Under an intergovernmental agreement (September 21, 1984) between the River District, Grand County Board of County Commissioners, and Middle Park Water Conservancy District, the River District has agreed to give equal consideration to the construction of reservoir storage alternatives on Big Muddy Creek north of the town of Kremmling. After reviewing the results of technical feasibility studies, this draft environmental statement (DEIS), and comments received, and after consultation with the appropriate permitting agencies, a final decision will be made concerning the River District's preferred site for construction. If that site is on Public Land, the necessary application will be filed with the BLM. This document has been written to satisfy NEPA compliance requirements for either a Rock Creek site or a Muddy Creek site.

1.3.6. <u>River District - Denver Water Board Agreement of December 15, 1986</u>. On December 15, 1986, the River District, Northern Colorado Water Conservancy District, and the Denver Water Board concluded an agreement intended to resolve a number of East Slope/West Slope water issues. The objectives of the agreement include reducing the impact of diverting water from western Colorado to the Denver area, assisting Denver in meeting its short-term water needs, and providing the River District with funds to meet its statutory purposes.

Under terms of the agreement, the Denver Water Board will lease approximately 90 percent of the capacity and yield from a reservoir constructed by the River District at either Rock Creek or Muddy Creek. The River District will retain approximately 10 percent of the reservoir capacity and yield for West Slope uses. The lease is for a 25-year period at a base price of $250 per acre-foot per year, with the base price indexed to a mutually agreeable index. The base price will be applied to the increase in Denver system yield made possible through the lease (approximately 15,000 acre-feet). Following this 25-year period, Denver could renew the lease for any portion of the firm annual yield that the River District determines is not necessary for western Colorado use. Under terms of the agreement, the River District will operate and maintain the reservoir (see Section 2.4.7 for additional information).

Additional provisions of the agreement call for the River District, Denver, and the Northern Colorado Water Conservancy District to make a joint application to the Colorado Water Resources and Power Development Authority for a feasibility study of water supply options in the Fraser River Valley. Also, Denver, the River District, and Northern will continue to discuss and negotiate mutual solutions to minimum streamflow maintenance on the Colorado River in Grand County.

1.4. Reservoirs and Water Use

1.4.1. Purpose of Storage. The diversion of surface water originating in the Colorado River drainage over or through the Continental Divide to water users east of the Continental Divide, has been the subject of intense controversy for many decades. Within the State of Colorado, most of the available surface-water supplies originate in the tributaries of the Colorado River west of the Continental Divide. However, most of the population and economic activity within the State are east of the Continental Divide. This imbalance between the available surface water west of the Continental Divide and the demand east of the Continental Divide has resulted in the construction of transmountain diversion projects. The first major project was the construction of the Moffat Tunnel water diversion project by the Denver Water Department in the 1930's. It was also in the 1930's that the C-BT Project was proposed to divert the Colorado River through the Continental Divide for agricultural uses in northeastern Colorado.

In response to proposals to build the C-BT Project, western Colorado interests formed the Western Colorado Protective Association in 1933 to protect western Colorado's water and economic interests in court and in the State and Federal legislatures. The C-BT Project was opposed in western Colorado because of fears that the proposed project would impact water supplies, fisheries, and future economic development in western Colorado. The debate and negotiations over the Federal authorization of the C-BT Project resulted in a compromise where the authorized features of this project included 100,000 acre-feet of storage capacity in Green Mountain Reservoir allocated to power generation and other water uses within the Colorado River Basin.

1.4.2. Use of Storage in Western Colorado. The Colorado River and its tributaries experience widely varying seasonal fluctuations in flows. The spring runoff period of May through mid-July provides approximately 75 percent of the total annual flow. During this period there is usually a surplus of available water; however, during the late summer and fall when streamflow is low, demand continues or increases and often exceeds supply. Therefore, reservoir storage redistributes the spring surplus to this period of demand and improves the reliability of the available water supply to present and prospective water users within the basin.

Under Colorado's appropriative doctrine of water law, water is prioritized on a first-in-time, first-in-right basis. That is, those who own

water rights which were filed for and/or placed into beneficial use earliest have the greatest probability of being able to divert water throughout the year. A "junior" upstream right may be required to stop diverting water if it causes the streamflow to fall below the amount to which a downstream "senior" water rights holder is entitled. On the main stem Colorado River in Colorado, two major downstream water rights control the administration of the river. These two water rights are the Shoshone Power Plant which has a right for 1,250 cfs with a priority date of 1902 and the Grand Valley irrigation water rights (collectively referred to as the Cameo call). The Grand Valley irrigation rights have a total call of approximately 2,000 cfs with priority dates senior to 1910. The hydrology of the Colorado River is more fully described in Chapter 3.

The existence of these large senior water rights primarily determines the need for and use of storage in the Colorado River drainage. Water users with water rights junior to about 1910 can not obtain a 365-day supply without recourse to stored water when their rights are called out of priority by downstream users with senior rights. Since the majority of the Denver Water Board's rights are junior to 1910, Denver must provide West Slope storage or some other means to augment Colorado River flows at the point of the downstream senior calls equal to the amount of water diverted out of priority.

In 1986 the Denver Water Board and the Public Service Company of Colorado, which owns and operates the Shoshone Hydroelectric Plant, negotiated an agreement to subordinate the senior Public Service Company water right at Shoshone during those periods when "the Board determines that water available to the Board's diversion and storage facilities is critically impacted by Public Service's senior water right. . . ." While this subordination will be exercised ". . . only if no vested downstream or upstream water decrees in Colorado will be injured thereby," the full impact of this agreement on the administration of the Colorado River remains to be determined.

The construction of storage offsets potential impacts of transmountain diversions by providing a source of water that can be used by present and future western Colorado enterprises that must obtain a reliable source of water when their water rights are not in priority. It is for this reason that the River District and other western Colorado water resource organizations have demanded West Slope storage as a part of the transmountain diversion projects. In addition, the existence of West Slope storage serves as a buffer against potential West Slope shortages during periods of prolonged drought.

1.5. Related Projects

1.5.1. Windy Gap and Green Mountain. A number of different water projects would be related to or impacted by the operation of the proposed project. As described in Section 1.3, the proposed project is part of the mitigation package related to the Windy Gap Project.

The proposed reservoir also would be operated in conjunction with the Bureau of Reclamation's Green Mountain Reservoir. An environmental statement covering the marketing of Green Mountain Reservoir water has been prepared by the Bureau of Reclamation. The draft environmental statement was published September 6, 1985, as INT-DES-85-40. This document describes the hydrology of streams in Summit, Grand, and Eagle counties affected by Green Mountain water sales and provides a systemwide hydrologic analysis of Green Mountain Reservoir and the Colorado River system. This hydrologic analysis (USDI/BR, 1985) is summarized and related to the operation of the proposed project in Chapter 3 and is specifically incorporated by reference pursuant to 40 CFR 1502.21. This material is available for review at the Forest Supervisor's Office, Routt National Forest, 29887 West U. S. 40, Suite 20, Steamboat Springs, Colorado.

1.5.2. Metropolitan Denver Water Supply Systemwide DEIS. The U. S. Army Corps of Engineers has prepared the Metropolitan Denver Water Supply DEIS (MDWS/DEIS) disclosing the impacts of the development of additional water sources needed to supply water for future growth to the metropolitan Denver area (including all or parts of Adams, Arapahoe, Boulder, Denver, Douglas, Jefferson, and Weld counties). The MDWS/DEIS describes both system-wide and site-specific alternatives to supply this water. Included in the various system-wide alternatives, as projects to meet metropolitan Denver's near-term water needs, are West Slope Exchanges. These exchanges are described in the MDWS/DEIS Appendix 4 - Water Sources for Future Supply, Appendix 4B - Water Sources Selected for Use in Alternative Scenarios, Volume 5 - Blue River Exchange/Joint Use Reservoir. This document identifies both the proposed Rock Creek and Muddy Creek (Wolford Mountain) reservoirs as components in a Blue River Exchange Scenario (U. S. Army Corps of Engineers, 1986).

Data on West Slope exchanges in the MDWS/DEIS are specifically incorporated by reference pursuant to 40 CFR 1502.21. This material is available for review at the Forest Supervisor's office, Routt National Forest, 29587 West U. S. 40, Suite 20, Steamboat Springs, CO 80487.

As discussed in Sections 1.2 and 1.3.6, the River District has agreed to lease a major portion of the yield of the Rock Creek or Muddy Creek reservoir to the Denver Water Board for a 25-year period. The Water Board could use either reservoir in support of exchanges to accomplish transmountain diversions by making releases which would permit an equivalent amount of water to be either retained in reservoirs owned by Denver or diverted under direct flow decrees owned by Denver.

1.5.3. Joint-Use Reservoir and Green Mountain Exchange Projects. At the request of the River District and the Board of Water Commissioners for the City and County of Denver, the Colorado Water Resources and Power Development Authority is conducting a study of the Joint-Use Reservoir and Green Mountain Exchange projects. The study will provide reconnaissance level engineering and hydrology information on these projects.

The objective of the Joint-Use Reservoir Project is to provide additional water to Western Colorado and the Denver Metropolitan Area. The reservoir(s) should have the capability and flexibility of increasing the firm annual yield of the Dillon Reservoir/Roberts Tunnel System by about 15,000 acre-feet and providing an additional 15,000 acre-feet of firm annual yield for use in Western Colorado. The Denver Water Board-River District Agreement (Section 1.3.6) will defer (or replace) joint use reservoir requirements.

The Green Mountain Exchange Project is intended as a potential alternative to previously identified water diversion and storage projects. The objective of this exchange is to provide additional water to Dillon Reservoir and the Denver Metropolitan Area. This could be accomplished by regulating existing flows and by pumping water directly from Green Mountain Reservoir while providing a new reservoir(s) to replace the existing functions of Green Mountain Reservoir.

The upper Colorado River system was examined by the Colorado Water Resources and Power Development Authority for candidate sites. Unregulated streams (Muddy Creek, Troublesome Creek, and the Piney River) were considered along with previously studied reservoir sites. Nine sites were identified during the development of a plan of study, including:

- Red Mountain on the Colorado River
- Haypark on East Troublesome Creek
- Wolford Mountain - Sites A and C on Muddy Creek
- Azure on the Colorado River
- Lower Piney on the Piney River
- Una on the Colorado River
- Wolcott on Alkali Creek
- Iron Mountain on Homestake Creek

The selection of these nine sites was based on the following:

1. Conditional water rights or claimed water rights on each site are held by either the River District, Middle Park Water Conservancy District or Denver (Haypark, Wolford, Azure, Wolcott, and Iron Mountain).

2. Sites were identified in the past by the Bureau of Reclamation as having potential storage capacity to meet the objectives of the study (Red Mountain).

3. Recent studies on several of the projects provide a good data base for evaluation and comparison and could be included at little additional cost (Azure and Una).

The information developed in the joint use/exchange study should clearly identify one or two sites which meet the project objectives and are suitable to proceed through the feasibility study process (Boyle, 1986).

1.6. Scope of Public Issues and Management Concerns Identified and Addressed

1.6.1. General. The scope of public issues and management concerns to be identified and addressed in this EIS was determined by a variety of processes. These include the litigation and negotiations summarized in Section 1.3, the historical use of storage in western Colorado and its ramifications as described in Section 1.4, and related environmental compliance activities discussed in Section 1.5. Most importantly, a series of public scoping meetings were held and followup interviews were conducted with Federal, State, and local agencies as well as with interested and concerned individuals in the affected area. Public scoping meetings were held in Kremmling, Colorado, on July 31, 1985; Yampa, Colorado, on August 1, 1985, and Denver, Colorado, on August 2, 1985. In addition, an agency scoping meeting was held in Denver, Colorado, on August 2, 1985. A special scoping session was held on October 10, 1985, in Frisco, Colorado, for representatives of the Denver Board of Water Commissioners and Metropolitan Water Providers. EIS study team meetings and meetings of a Wildlife Work Group have been attended by representatives of many Federal and State agencies. This has also contributed to the identification of environmental issues related to the proposed action. Details of the scoping process and consultation with others are presented in Chapter 7.

1.6.2. Issues and Management Concerns. As a result of scoping, internal staff review, and consultation with cooperating agencies, the Forest Service determined that major environmental issues and management concerns for the Rock Creek site and reasonable alternative sites could be grouped into the categories of: water, engineering, soils, wildlife/ vegetation, fish habitat, recreation/ social, and economic. Many concerns were raised during scoping and staff review of the proposed projects. A generalized listing of the major issues which could have a significant influence on site selection is included below. All concerns are addressed in this document.

Water - Stream channel stability, morphology, and equilibrium

- Chemical and physical water quality conditions during and after construction

- Salinity effects in Lower Colorado River main stem

Engineering - Dam safety, flood risk, hazard rating, and seismic activity

- Facilities relocation

- Post-project traffic patterns

- Location, development, and reclamation of materials borrow sources

Soils - Compatibility of soils with projected uses

- Reservoir shoreline stability

Wildlife/ Vegetation	-	Wildlife values, disturbance of winter/summer range and habitat, migration, and/or distribution patterns of elk and deer
	-	Impact and loss of wetland, riparian habitat, and threatened and endangered plants
Fishery	-	Impact on or loss of stream habitat and characteristics of reservoir habitat
	-	Projected fishing use of affected area (self-sustaining v. stocking)
Recreation/ Social	-	Effect of reservoir operations on recreation use (rafting, boating, fishing, etc.)
	-	Recreation potential and projected use
	-	Land use changes and impacts on private lands
	-	Visual impacts
	-	Cultural resources
Economic	-	Efficiency and impact of alternative reservoirs

The scoping process and identification of issues resulted in a determination that analytical work was required in several disciplinary areas: hydrology and reservoir operations, flood control, river hydraulics and channel stability, geology, air quality, water quality, aquatic biology, wildlife biology, vegetation, soils, visual resources, cultural resources, recreation, social, and economics.

1.7. Land Use Plans

1.7.1. Forest Plan - Routt National Forest. The long-term direction for managing the Routt National Forest is contained in the Forest's Land and Resource Management Plan (Forest Plan). This Forest Plan was approved on November 15, 1983 (USDA/FS, 1983). It defines goals, objectives, general Forest direction, and specific Management Area direction for the Routt National Forest. United States Code 1604 (i) requires that ". . . all permits, contracts, and other instruments for occupancy of National Forest System lands must be consistent with the land management plans. . . ." The impacts disclosed in this EIS will determine if this proposal is in conformance with the Forest Plan or if permitting this proposal or any alternative would require amending the Forest Plan pursuant to USC 1604 (f) (4) (USDA/FS, 1983). The relationship of the Rock Creek project to the Forest Plan is discussed in Sections 2.4.8 and 3.10. Potential impacts of the proposed action on the Forest Plan are discussed in Section 4.3.9.

1.7.2. Bureau of Land Management Resource Management Plan--Kremmling Resource Area. The Bureau of Land Management (BLM) has developed the Kremmling Resource Management Plan (RMP) which will provide a framework for future management of the public lands and resources in the Kremmling Resource Area. Potential construction of a dam and reservoir on Muddy Creek, west of Kremmling, Colorado, must consider the objectives and requirements of this RMP. The RMP framework for future management will be established by determining which resources will be given management emphasis in the various parts, or priority areas, of the resource area. Each priority area would allow for other resources to be developed or protected to the maximum extent consistent with the resource emphasized in that area. Resource development would be managed within the principles of multiple use and sustained yield. (USDI/BLM, 1984) The relationship of the Muddy Creek project to the Resource Management Plan is described in Sections 2.5.8 and 3.10. Potential impacts of the Muddy Creek project on the Resource Management Plan are discussed in Section 4.4.9.

1.8. Permit Requirements

In addition to Special Use Permits required from the Federal agencies responsible for resource management of lands required for the proposed construction, additional permits or approvals may be necessary to implement any of the alternatives. These Federal, State, and local agency requirements are summarized in Table 1.8.1.

Table 1.8.1
Reviews, Permits, and Licenses Required by Federal, State, and Local Agencies

Agency	Act of regulation	Requirement
U. S. Army Corps of Engineers	Clean Water Act	Discharge of dredge and fill material (Dept. of the Army Permit under Section 404)
	National Environmental Policy Act	
U. S. Environmental Protection Agency	National Environmental Policy Act and Federal Water Pollution Control Act	Environmental Impact Statement, 404 Permit Application, Colorado Discharge System Permit, and State Water Quality Certificate (Section 401) review
USDI/Fish and Wildlife Service	Endangered Species Act, Fish and Wildlife Coordination Act, Wildlife Improvement Act, Migratory Bird Protection Act	Compliance with provisions of the Acts
	National Environmental Policy Act	Environmental Impact Statement
USDI/Bureau of Land Management	Federal Land Policy and Management Act of 1976	Compliance with provisions of the Act
	National Environmental Policy Act	Environmental Impact Statement
USDA/Forest Service	Federal Land Policy and Management Act of 1976	Compliance with provisions of the Act Environmental Impact Statement
	National Environmental Policy Act	A Special Use Permit will be the authorizing document for the construction phase Maintenance of the structure normally is authorized by an easement
	American Indian Religious Freedom Act of 1978	Notify appropriate tribes
	Archaeological Resource Protection Act of 1979	ARPA required
Historic Preservation Office	National Historic Preservation Act, Section 106 and Executive Order 11593, Section 2(b) 36 Code of Federal Regulations 800	Compliance with provisions of the Act and Executive Order
Air Pollution Control Division, Colorado Department of Health	Colorado Revised Statutes 1973, 25-7-123, 5 Colorado Code of Regulations 1001-3, Regulation No. 1	Open Burning Permit
	Colorado Revised Statutes 1973, 25-7-112, 5 Colorado Code of Regulations 1001-5, Regulation No. 3	Air Contaminant Emissions Notice
Water Quality Control Division, Colorado Department of Health	Federal Water Pollution Control Act; Clean Water Act; Colorado Revised Statutes 1973, 25-8-501 through 508, 5 Colorado Code of Regulations 1002-2	Colorado Discharge System Permit which fulfills requirements for National Pollutant Discharge Elimination System Permit
	Federal Water Pollution Control Act, Section 401, Colorado Water Quality Control Act, Colorado Revised Statutes 25-8-302(f)	Water Quality Certificate (401 Certificate) required prior to issuance of 404 Permit by the Corps of Engineers
	Colorado Revised Statutes 1973, 25-1-107, 5 Colorado Code of Regulations 1003-1 (location and construction of water works)	100-Year Flood Plain Certification

(continued)

Table 1.8.1 (continued)
Reviews, Permits, and Licenses Required by Federal, State, and Local Agencies

Agency	Act of regulation	Requirement
State Engineer, Division of Water Resources, Colorado Dept. of Natural Resources	Colorado Revised Statutes 1973, 37-87-105, 2 Colorado Code of Regulations 402-1	Approval of plans for dam and reservoir
	Colorado Revised Statutes 1973, 37-87-122, 2 Colorado Code of Regulations 402-1	Permit to construct temporary erosion control dams
Mined Land Reclamation Division, Colorado Department of Natural Resources	Colorado Revised Statutes 1973, 34-32-100 et seq., 2 Colorado Code of Regulations 4071, Rules 2, 3, and 4	Limited Impact, Regular, or Special Mining and Reclamation Permit for riprap, sand, and gravel for project
Colorado Division of Wildlife, Colorado Department of Natural Resources	Colorado Revised Statutes 1973, 34-32-101 et seq., Colorado Code of Regulations 2-04-11	Compliance with Federal Water Pollution Control Act
Colorado State Historic Preservation Office	Colorado Revised Statutes 1973, 24-80.1-101 through 108; 24-65.1-104(6), 201(C), 202(3), 302	Cultural resource clearance
Colorado Soil Conservation Board	Colorado Revised Statutes 1973, 35-72-101 et seq.	Prevent blowing soil conditions as directed
Colorado Division of Labor, Public Safety Section	Colorado Revised Statutes 1973, 9-7-101 et seq., 7 Colorado Code of Regulations 1101-9	Permit for explosive materials
Routt County, Colorado	Comprehensive plan	Conform to plan
Grand County, Colorado	County 1041 regulations	Regular Impact Permit
	County regulations	Rezoning to impact zone with underlying agriculture zone
	County regulations	County Road Access Permit
	County regulations	Road Use Permit (overweight and overlength vehicle)
	County regulations and Uniform Building Code	Obtain necessary Building Permits
	County regulations	Vacation and dedication of county roads

2.0. DESCRIPTION OF ALTERNATIVES

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2.0. DESCRIPTION OF ALTERNATIVES

2.1. Introduction

This chapter presents the alternatives evaluated as a part of the NEPA compliance process, including alternatives considered but eliminated from further consideration. This chapter also includes a description of related projects being proposed or studied by other agencies within the state of Colorado, but not considered as reasonable alternatives for this EIS.

To determine alternatives that would be reasonable and feasible considering the Court decisions and negotiations summarized in Chapter 1, a set of criteria were established. First, the alternative should provide approximately the same water yield as anticipated with the Azure Project (about 20,000 acre-feet, see Section 1.3.2). Second, the total project cost and cost per acre-foot of water yield should be reasonable in relation to the Azure-Windy Gap Supplemental Agreement (see Section 1.3.5). Finally, the project should be located within reasonable proximity of Windy Gap, the project being mitigated (see Fig. 1.3.1). Using these criteria a number of alternative sites and enlargements of existing reservoirs were considered. Other than the Rock Creek sites in Routt County, the only reasonable alternative is on Muddy Creek in Grand County.

Section 2.2 describes the Azure Project and other alternatives eliminated from detail study. Section 2.3 describes the no-action alternative. Sections 2.4 and 2.5 describe the proposed reservoir on Rock Creek and the alternative reservoir on Muddy Creek. Section 2.6 compares the physical features of the alternative reservoirs. Section 2.7 provides a summary of impacts in matrix form, and Section 2.8 indicates that the Forest Service has not identified a preferred alternative in this draft environmental statement. A preferred alternative will be identified in the Final Environmental Impact Statement.

2.2. Alternatives Considered but Eliminated from Detailed Study

2.2.1. Azure Project Alternatives. From May 1980 through September 1983, the River District and the Northern Colorado Water Conservancy District Municipal Subdistrict (Municipal Subdistrict) investigated reservoir alternatives at the Azure damsite.

The Azure site had long been recognized as a possible damsite. The site was located in a steep and narrow section of Lower Gore Canyon, about 1,500 feet downstream from the entrance (Fig. 1.3.1). The site was considered suitable for a concrete arch dam. An existing Denver and Rio Grande Western railroad extends along the right bank of the Colorado River past the damsite. This railroad is in frequent use. The maximum normal reservoir elevation was selected to be at elevation 7,096.0, which would have required relocation of the railroad. This relocation would be accomplished by the construction of a 9,400-foot tunnel and a 2,000-foot open cut at the upper end which would need to be completed prior to major construction at the dam site. A geologic reconnaissance indicated that the tunnel cut through both competent gneiss and sedimentary rock and also weak sedimentary rock.

The River District and the Municipal Subdistrict studied several different configurations for a project at the Azure site. The following sections describe the Azure Project alternatives and summarize the evaluation of these alternatives as a basis for eliminating the Azure Project from further consideration in this document. The environmental characteristics of the site are described in detail in an environmental report, Azure Hydroelectric Project, following FERC Appendix E requirements (Colorado River Water Conservation District and Municipal Subdistrict, 1982).

2.2.1.1. Small Azure Reservoir. The small Azure configuration proposed a 98-foot concrete arch dam that would have an active storage capacity of approximately 23,000 acre-feet. The small Azure configuration would not require the relocation of the existing Denver and Rio Grande Railroad that runs through Gore Canyon. The small Azure configuration had a water yield of approximately 20,000 acre-feet per year. Engineering and construction costs for the project were estimated to be $30 million (IECO, 1982), not including hydroelectric power features. Hydroelectric power on the small configuration was studied but was considered marginal due to the high cost of construction of the power plant and transmission features and low head available (less than 100 feet).

2.2.1.2. Large Azure Reservoir. The storage capacity of the small Azure Reservoir was limited by the existing Denver and Rio Grande Railroad. The large Azure configuration proposed the relocation of the railroad through a tunnel bypassing the reservoir site. This would allow for the construction of a much larger reservoir.

The large Azure configuration proposed the construction of a 200-foot concrete arch dam providing a reservoir with a capacity of approximately 90,000 acre-feet and a firm annual yield of 75,000 to 80,000 acre-feet per year. The large Azure configuration would have included a 32-megawatt power plant. The engineering and construction cost estimate for the railroad relocation, dam and reservoir, and power feature was $102 million.

2.2.1.3. Azure with Pumped Storage. The topographic and geologic conditions at the Azure site provided the opportunity for pumped storage, a concept which calls for pumping water from a lower reservoir to a higher reservoir during periods when surplus energy is available on the power grid (off-peak times). This water would then be released back to the lower reservoir to generate hydroelectric power at a time when there is need for power on the grid such as the mid-afternoon peak.

A pumped storage component of Azure could be constructed with either the small or large Azure configuration. The upper reservoir component of the Azure with pumped storage configuration would be located on the Trough Road about 1,180 feet higher than the elevation of the Azure damsite. The Azure with pumped storage component would provide a generating capacity of up to 800 megawatts at a cost of approximately $1 billion.

2.2.1.4. Evaluation of Azure Alternatives. In July 1983, the Municipal Subdistrict filed a major hydroelectric permit application with the Federal Energy Regulatory Commission (FERC). The application proposed a small Azure with pumped storage configuration.

The Grand County Board of County Commissioners, Northwest Colorado Council of Governments, the River District, and recreation interests objected to this project. Grand County and the recreation interests objected to the impacts the Azure Project would have on river-based recreation in Gore Canyon.

Middle Park, Grand County, and the River District objected to the project as being not in conformance with the April 30, 1980, agreement. Concern was expressed about the cost and complications of the project. It was believed that the project would encounter stiff opposition because of the environmental and recreation impacts of the project and because the project did not provide sufficient reservoir capacity for West Slope users.

After discussions between Grand County, River District, Middle Park, and the Municipal Subdistrict, all of the Azure alternatives were dropped from further development as alternatives for mitigation storage for the Windy Gap Project. The reasons for dropping Azure alternatives were:

1. The high cost of the project alternatives.

2. Impacts on recreation in the Gore Canyon.

3. Opposition to the project by local governmental officials, including Grand County.

4. Extensive time required for project permitting.

Because of the extensive history of review, Azure Project alternatives have not been considered further in this EIS.

2.2.2. Other Alternatives Eliminated from Detailed Study. During the negotiations between the River District and the Municipal Subdistrict, a number of projects were considered. During public scoping meetings for this EIS many of these same projects were suggested as alternatives to construction of dams on Rock Creek or Muddy Creek. The following sections summarize other alternatives considered and the basis for eliminating them from detailed study under this EIS.

2.2.2.1. Enlargement of Existing Reservoirs. One alternative brought up in scoping was the possibility of adding to the storage volume of existing reservoirs. However, there are few existing small reservoirs in the project vicinity. These small reservoirs serve primarily agricultural uses. An example of a reservoir that might be enlarged is Red Dirt Reservoir located on Red Dirt Creek in the Muddy Creek drainage.

Enlargement of Red Dirt Reservoir is estimated to cost $1,191,300 and would provide 800 acre-feet per year increased yield. Based on the investigation of enlarging Red Dirt Reservoir, to obtain a comparable yield to Rock Creek or Muddy Creek alternatives, approximately 20 to 25 reservoirs would have to be enlarged at an estimated construction cost of $27 million (Morrison-Knudsen Engineers, Inc., 1986). This alternative was eliminated from further consideration because it could not provide sufficient water at reasonable cost.

2.2.2.2. Change Legal and/or Judicial Framework. It was also suggested during scoping that it might be possible to implement changes to existing legal or judicial controls as an alternative to reservoir construction. Given the lengthy and complex series of legal actions and negotiations related to the Windy Gap Project that form the basis for the proposed action (see Section 1.3), an alternative that envisions changes to the existing legal and judicial framework would be speculative.

It must be recognized that the Azure-Windy Gap Agreement which provides the financial basis for this project (see Section 1.3.5) also restricts the range of options for which these funds can be used. These restrictions were considered in developing the alternative screening criteria of Section 2.1. Simply changing the legal or judicial framework of the agreements summarized in Chapter 1 would not provide additional water for future demands in the Denver metropolitan area (as documented in the Metropolitan Denver Water Supply Systemwide DEIS) or for future West Slope demands as identified in Section 2.4.7.

2.2.2.3. Haypark Reservoir. The Haypark Reservoir site is located on the East Fork of Troublesome Creek in Grand County. Middle Park Water Conservancy District holds conditional water rights for the reservoir.

The reservoir site was investigated by the Bureau of Reclamation from 1949-1953 as a part of the Cliffs-Divide project and was further investigated by the River District, Municipal Subdistrict, and the Colorado Water and Power Development Authority. The dam and reservoir site is located in the Middle Park basin to the east of the Park Range uplift. In general, the basin consists of Mesozoic and Lower Tertiary sedimentary rock and extrusive igneous rocks.

The reservoir basin would accommodate a reservoir site up to 70,000 acre-feet. The historical annual discharge of East Troublesome Creek at the damsite is about 21,000 acre-feet per year. Investigations showed that a 185-foot high dam at the Haypark site would impound a reservoir of up to 31,000 acre-feet providing a firm yield of approximately 12,000 acre-feet per year. The cost of this reservoir was estimated at $60 million.

The reservoir was not considered as an alternative because of the high cost of the project and geologic concerns with landslides within the reservoir basin associated with steep and unstable slopes.

2.2.2.4. Muddy Creek Site A. A reservoir on Muddy Creek (Site A) was considered by the Colorado Water Resources and Power Development Authority as part of the investigations for the joint use reservoir and Green Mountain exchange projects (see Section 1.5.3) (Boyle, 1986). As envisioned in the Boyle report, Site A would be located on Muddy Creek, approximately 1 mile upstream from Kremmling. A 117-foot high dam on Muddy Creek at Site A would create a reservoir of 80,000 ac-ft with an estimated yield of 64,000 ac-ft/yr. A 137-foot high dam would create a reservoir of 119,600 ac-ft with an estimated yield of 84,000 ac-ft/yr. Approximately 40 to 50 percent of the yield would be provided by water pumped from the Colorado River through 2.4 miles of pipeline. Without pumping, the estimated yield of the larger reservoir at Site A would be 40,000 ac-ft/yr. Average annual streamflow at the dam site was estimated to be 63,600 ac-ft/yr for Muddy Creek from analysis of historical records. Colorado River discharge at the potential diversion point was estimated to be 678,000 ac-ft/yr.

Approximately 4 miles of U.S. Highway 40 would have to be relocated. Some ranch houses and cropland would be inundated by the reservoir.

Major geologic considerations were centered around seismic concerns and seepage potential of the Antelope Pass Fault Group. This fault group has been reported as active by the Colorado Geological Survey. Recent studies for the Colorado River Water Conservation District cite evidence that movement was ancient, indicating no potential activity. Two faults of this group enter the reservoir area just upstream of the left abutment of the dam of Site A and could be paths for reservoir seepage. The proximity of the right abutment of the dam to the face of the bluff behind Kremmling, in light of the potentially active fault, raised concerns about stability of the abutment.

The Boyle (1986) report concludes that as a result of initial screening, the dimensions of this site would permit construction of an efficient dam size with respect to reservoir storage capacity, but there are geological concerns. "Questionable stability of the right abutment when saturated and possible reservoir seepage along a fault zone are of sufficient concern to justify elimination of this site from further consideration." The results of this initial screening of Site A support eliminating this site from further consideration under this environmental statement.

An additional large reservoir site about 3/4 miles upstream from Site A is now being considered as part of the Colorado Water Resources and Power Development Authority investigation. To be cost effective, the project would require diversion and pumping of water from the Colorado River. The project would store approximately 120,000 acre-feet, yield about 50,000 acre-feet, and cost about $90,000,000, which places the facility well beyond the reasonable range of size and cost considered feasible for this EIS.

2.2.2.5. DeBerard Reservoir. The DeBerard Reservoir site is located on Muddy Creek approximately 20 miles upstream of Kremmling. Middle Park Water Conservancy District holds conditional water rights for the reservoir.

The reservoir site was investigated by the Bureau of Reclamation from 1949-1953 as a part of the Cliffs-Divide project and was further investigated by the River District, Municipal Subdistrict, and the Colorado Water and Power Development Authority. The dam and reservoir site is located in a geologic setting similar to the Muddy Creek site.

The reservoir basin would accommodate a capacity of 22,500 acre-feet at a dam height of 86 feet. A 22,500 acre-feet reservoir would provide a yield of approximately 10,000 acre-feet per year. The 22,500 acre-feet reservoir would cost approximately $30 million. Because of the topography of the damsite, building a reservoir larger than the 22,500 acre-feet size becomes extremely expensive, effectively limiting the reservoir size to 22,500 acre-feet.

The reservoir was not considered as an alternative because of the limited size and yield available at the reservoir site and high cost of the reservoir.

2.2.2.6. <u>Projects on the Eagle River</u>. Storage projects on the Eagle River were considered. The River District holds conditional water decrees for several projects in the Eagle River drainage, including Iron Mountain Reservoir located on Homestake Creek above the town of Minturn.

The Iron Mountain Reservoir site has a storage capacity of up to 100,000 acre-feet with a yield of up to 30,000 acre-feet per year. However, the project is very expensive, up to $200 million for the large reservoir. Geologic concerns within the basin could preclude or make it even more costly to build a dam at the Iron Mountain Reservoir site (Boyle, 1986). Projects on the Eagle River are also considered to be located out of geographic proximity of Windy Gap.

2.2.2.7. <u>Projects Upstream of Kremmling on the Blue and Colorado Rivers</u>. Storage projects on the Blue and Colorado rivers upstream of Kremmling were also considered. However, no candidate projects were identified. The Blue and Colorado rivers upstream of Kremmling are already heavily impacted by existing and planned projects which effectively utilize the available water supply.

Two major projects exist on the Blue River: Green Mountain Reservoir, a component of the Colorado-Big Thompson Project, and Denver's Dillon Reservoir/Roberts Tunnel Collection System. These two projects, as well as existing in-basin uses and a small transmountain diversion on the Upper Blue River by Colorado Springs, utilize the available water supply. These projects and associated impacts are discussed in the Bureau of Reclamation's EIS Supplement for Water Sales from Green Mountain Reservoir (USDI/BR, 1985).

The upper reaches of the Colorado River are impacted by four major projects, all transmountain diversions: the Colorado-Big Thompson Project, the Windy Gap Project, Denver's Moffat Tunnel Collection System, and Denver's Williams Fork Reservoir and diversion system. Also, Denver has

plans to expand the Williams Fork diversion system. In all but very wet years, these projects take the available water supply.

The River District is investigating small storage sites on the Upper Fraser as a possible solution to the water problems in the Upper Fraser River. However, this reservoir, if constructed, would be used primarily to manage or regulate river flows rather than provide additional storage.

2.3. No-Action Alternative

The no-action alternative assumes that a permit for construction of a dam and reservoir would not be issued for any site on either Rock Creek (U. S. Forest Service) or Muddy Creek (Bureau of Land Management). As required by NEPA, the no-action alternative provides a baseline for analysis of impacts in Chapter 4. Under the no-action conditions the River District would be required to initiate a variety of legal and institutional proceedings related to the adjudication and negotiations outlined in Chapter 1. These proceedings would involve additional adjudication under the Azure-Windy Gap Supplemental Agreement of March 29, 1985 (Section 1.3.5).

2.4. Rock Creek Reservoir--Applicant's Proposed Action

The Rock Creek project is the River District's (Applicant's) proposed action. At a meeting of the River District Board on January 28, 1987, the Board indicated an initial preference for the Rock Creek site. Selection of Rock Creek as the preferred site at that time was in response to a request from the Forest Service and based on review of engineering feasibility studies and a preliminary assessment of potential environmental impacts and mitigation measures. The Board of Commissioners of Grand County and the Middle Park Water Conservancy District (signatories to the 1984 intergovernmental agreement--see Section 1.3.5) have also indicated their support for a reservoir on Rock Creek. In exchange, the River District will support the future development of a large reservoir on Muddy Creek, if technically and economically feasible, and work toward developing structural and/or nonstructural solutions to water problems in the Upper Fraser Valley. As outlined in Section 1.3.5, after consultation with the appropriate permitting agencies the River District will review the selection of Rock Creek as a preferred site prior to completion of the final EIS.

2.4.1. Dam and Reservoir. The Rock Creek Reservoir sites are located on Rock Creek, a tributary to the Colorado River, in Routt County and within the Yampa Ranger District of the Routt National Forest. The area is in a canyon section of the Rock Creek Valley, on the western flank of the Gore Range, about 7 miles west of Gore Pass and 12 miles west of the town of Kremmling, Colorado. The potential dam sites are approximately 12 miles upstream from the confluence with the Colorado River. The preferred site, Dam Site B (see Fig. 2.4.1) lies at the point where Rock Creek changes from a meandering stream channel to a steep canyon. The proposed dam would be

constructed of roller-compacted concrete (RCC), a dam construction technique that produces a concrete gravity structure using primarily earth construction techniques. Much of the information in Section 2.4 has been extracted from "Report on Feasibility Investigations Rock Creek Dam Project" (Morrison-Knudsen Engineers, Inc., 1986).

The Rock Creek Dam would be 172 feet high from the streambed to a crest elevation of 8690 feet (see Fig. 2.4.2). Crest length would be 710 feet, and crest width would be 16 feet. The freeboard (height above normal high water elevation) would be 9 feet. The dam would contain a gross volume of about 180,000 cubic yards of concrete. Material for the dam would be obtained from the reservoir basin upstream of the dam and would have haul distances of 1 to 2 miles.

At the normal high water elevation (elev. 8681), the dam would impound 50,700 acre-feet of water, forming a reservoir of 1,070 acres and extending upstream about 3 miles from the dam. The total storage would include approximately 500 acre-feet reserved for silt accumulation, an amount estimated to be adequate for 50 years of storage. Fig. 2.4.3 provides a conceptual overview of the Rock Creek dam and reservoir. A 4,000 acre-foot conservation pool is also a feature of the reservoir. Only under extreme drought conditions (as represented in this document by a 1977 type year) would the Forest Service permit encroachment on this conservation pool.

The dam would include a spillway designed to pass a probable maximum flood (PMF) after routing through the reservoir. The PMF for the basin was determined to be 50,900 cfs peak inflow, with a total volume of 12,800 acre-feet. Routing the flood through the reservoir would create an 8.8-foot rise in reservoir surface level and produce a maximum outflow of 10,200 cfs. (See Section 4.2.3 for further details of reservoir hydrology and operations.)

During construction, diversion of the stream would be through a conduit located on the right side of the streambed (looking downstream) extending between upstream and downstream cofferdams. The portion of the conduit passing under the dam would be placed in a trench excavated into the rock foundation and embedded in conventional concrete. This section of the conduit would be used as the permanent outlet works conduit. After diversion, the conduit would be permanently plugged upstream of the outlet works intake. A temporary bypass pipe would be provided through the dam to pass required minimum flows in the interim period between plugging of the diversion channel and reservoir filling to the sill of the intake structure. Seepage inflow into the foundation area will be pumped into an upstream settling pond and returned to the stream.

In the Rock Creek valley area, approximately 1 to 2 miles upstream, excavated areas would be opened for obtaining the aggregates to be used in the dam. A new flow channel would be constructed along the east side of the valley and Rock Creek would be diverted into it. The area on the valley floor to the west would be cleared of vegetation on the surface and then excavated and removed from the valley floor to be processed into the appropriate gradation for use in roller-compacted concrete.

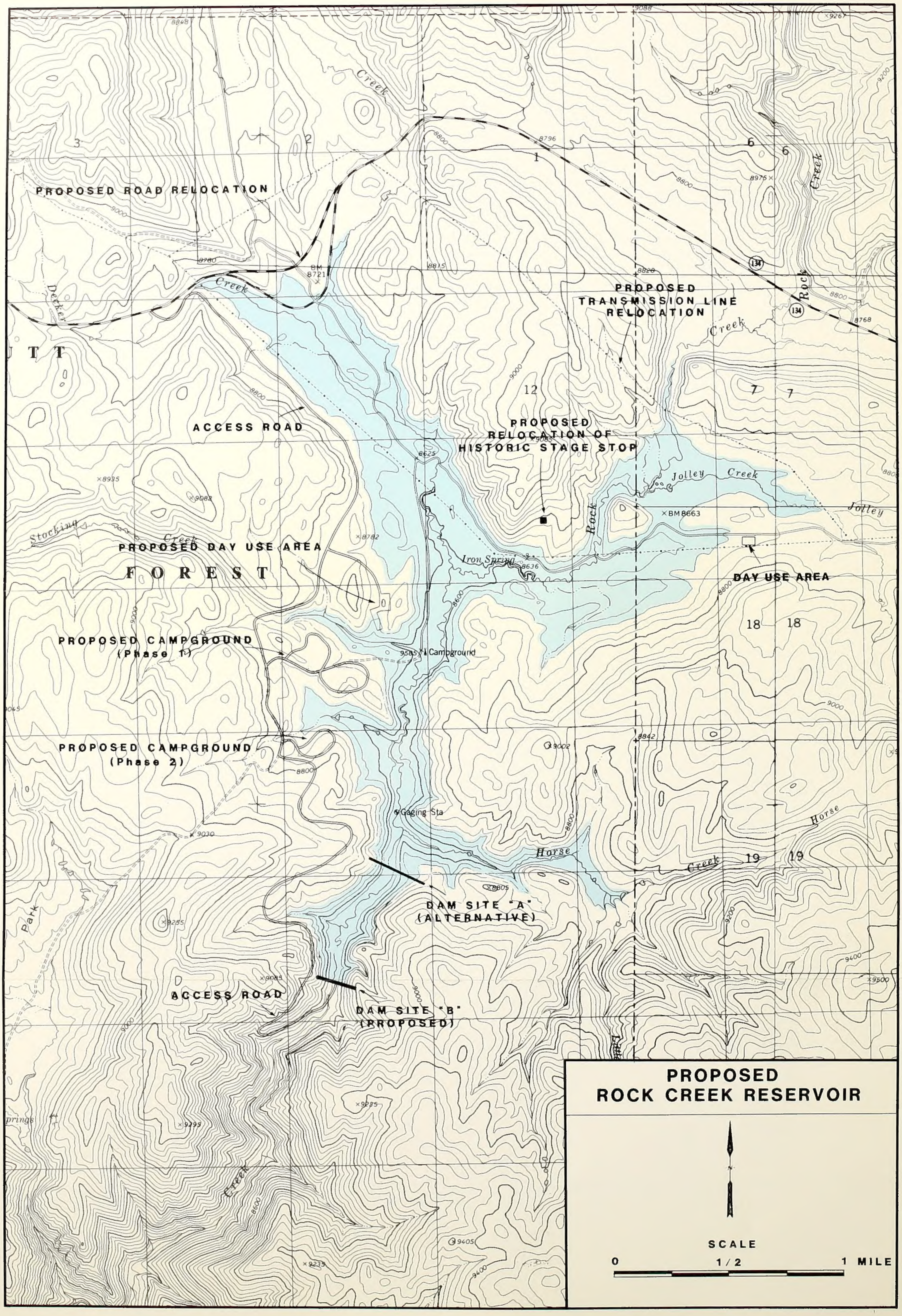


Figure 2.4.1 - Proposed Rock Creek Reservoir and Associated Components.

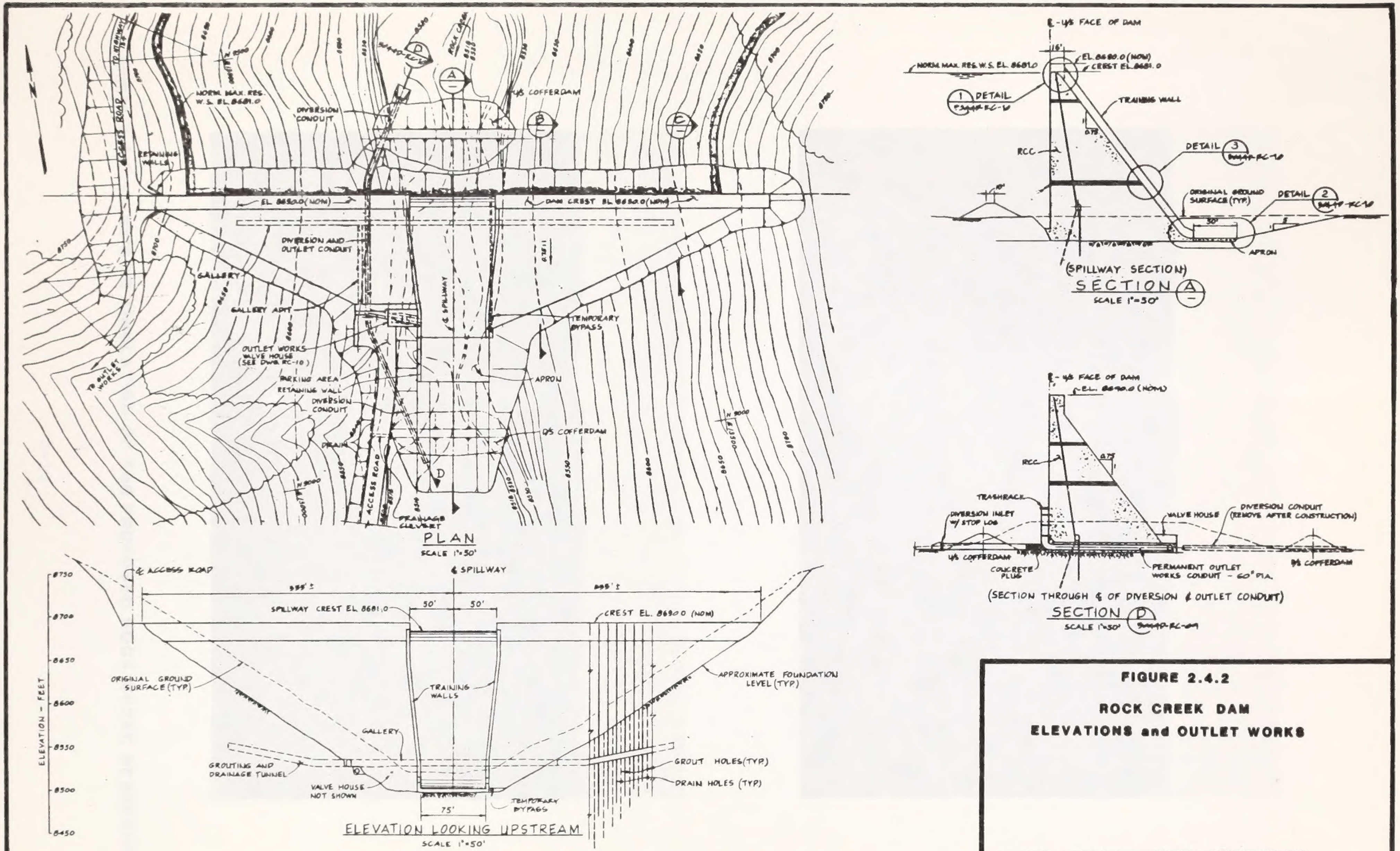


FIGURE 2.4.2

ROCK CREEK DAM

ELEVATIONS and OUTLET WORKS

Source: MORRISON-KNUDSEN ENGINEERS, INC.

Figure 2.4.3 - ARTIST'S SIMULATION OF THE PROPOSED ROCK CREEK RESERVOIR.

In certain areas the excavation would be under water and ponds will form. In other areas there may be dewatering by pumps into settling ponds where the water would return to the natural river channel at locations upstream of the dam. Permit restrictions would be met regarding discharge of sediment laden materials into the natural water course. Dikes would be placed along the diverted channel and ponds to prevent overtopping during high streamflow periods.

The outlet works would consist of a pipe riser intake attached to the upstream face of the dam connecting to the conduit passing under the dam and a valve structure at the downstream toe of the dam (Fig. 2.4.2). The outlet works conduit would bend at the toe of the dam so that the discharge is directed into the tailwater pool. The valve house would be located adjacent to the right spillway training wall and would contain 60-inch diameter and 12-inch diameter cone dispersion valves and their control equipment. The 60-inch valve would have a capacity of 300 cfs at minimum reservoir pool, while the 12-inch valve would regulate flows in the 0 to 30 cfs range, providing flow control during winter minimum flow periods.

2.4.2. Access Roads, Relocations, and Recreation Facilities. The proposed 50,700 acre-foot reservoir would inundate a 2-mile section of a 138 kv transmission line, a Forest Service access road, a ½-mile portion of State Highway 134, a small Forest Service campground, and a building that was formerly used as a stagecoach stop and has since been placed on the National Register of Historic Places (Fig. 2.4.1).

The 138 kv transmission line is owned and operated by the Western Area Power Administration. The proposed relocation alignment was selected as the route which provides the least visibility from State Highway 134 and is shown in Fig. 2.4.1.

An existing Routt National Forest access road presently exists at State Highway 134 near the northernmost tip of the proposed reservoir, parallels Rock Creek for about 1.5 miles before reaching a primitive campground, and then rises out of the valley into the Long Park area. The proposed road would serve as both Forest Service access and dam access and is shown in Fig. 2.4.1. The initial 2.8 miles would be a 20-foot wide gravel surfaced road, built up over the existing ground level, and provided with surface and cross drainage facilities. This road would not be kept open during the winter. The last mile of the road would consist of a single lane 10-foot-wide gravel road, which would be closed to the general public. Use of this road by the River District will be authorized through the Forest Service permitting system. The road would provide access to the west side and to the bottom of the dam, but not to the east side.

At the upstream end of the reservoir, a 0.5-mile section of State Highway 134 would be inundated by about 10 feet of water. As shown in Fig. 2.4.1, this section would be realigned by moving slightly uphill, and a widened section would be added as an observation turnout. The widened section would allow State vehicles easy access and facilitate snowplowing. The area would be designed to accommodate approximately 15 vehicles.

The historic stage stop (Fig. 2.4.1) is 41 feet below the normal high water elevation of 8681 feet. It is proposed that this building be moved from its present location, probably to higher ground near its present location just above the high water line of the reservoir. An alternative would be to catalogue the Stage Stop site and then allow it to be inundated. Since Forest Road 206 would provide the only public access to the east side of the reservoir, fisherman use and hiking in the vicinity of the Stage Stop is anticipated. A parking area for approximately 12 vehicles and a vault toilet would be provided.

An existing camp site is a primitive facility consisting of a pit toilet. A campground and picnic ground would be constructed at the area shown on Fig. 2.4.1. Initially, this campground would provide the equivalent of 50 camp units. The picnic ground would have a double lane boat launch ramp with parking for approximately 30 car and boat trailer combinations, a vault toilet, and 20 picnic units. Associated with the campground, a trail system would be constructed to connect campground loops, the picnic area, and heavily used adjacent shoreline.

A Memorandum of Understanding would be entered into between the Forest Service and the Colorado River Water Conservation District as part of an authorizing document for construction, operation, and maintenance of the reservoir, whereby use (occupancy) of the campground and picnic ground/boat ramp would be monitored for a period of years after the reservoir is filled. If and when campground occupancy meets and/or exceeds an established upper limit, a 25-unit campground extension would be constructed by the River District and a caretaker cabin could be constructed if deemed necessary by the Forest Service. At this time additional boat ramp/picnic ground units and parking could also be added.

At present the Forest Service has outlined the facilities considered appropriate if a reservoir were constructed on Rock Creek. However, a final decision on type, layout, and design of facilities has not been made. The Forest Service (Routt National Forest) specifically requests public comment on these suggested facilities during the review process for this document.

2.4.3. Operating Facilities and Project Administration. The operation, maintenance, and repair of the dam, outlet works, spillway, and other appurtenances would be the responsibility of the River District. The U.S. Forest Service and Routt National Forest would operate the campground facilities.

2.4.4. Rock Creek Construction Planning and Schedule

2.4.4.1. Materials Sources. Aggregates for the RCC mix would be obtained from the Rock Creek streambed deposits located from 6,000 to 10,000 feet upstream from the damsite. Screening tests on samples obtained from hand dug pits indicate an average overburden of 30 inches and aggregate deposits of from 5 to 10 feet thick. Most of the gravel material is under 3 inches and poorly graded. Crushing of oversized gravel and cobbles

would be required and the material would be separated into three size fractions and stockpiled. Approximately 260,000 cu. yd. of processed aggregates would be produced. Aggregates for use in the facing, bedding, and structural concrete mixes would be obtained from commercial sources in the vicinity of Kremmling. (Morrison-Knudsen Engineers, Inc., 1986)

It would be necessary to divert Rock Creek to the eastern edge of the valley to bypass the borrow area. Finger drains would be excavated across the borrow area, draining easterly to Rock Creek, in order to lower the water table. This would permit stripping the organic overburden and removing the aggregates in the dry.

2.4.4.2. Contractor's Plant and Operations. The contractor's work plan described below was developed for estimating purposes. This plan represents a reasonable approach for performing the work, however the contractor may be allowed with the concurrence of the Forest Service to vary the plan to efficiently perform the work with his particular equipment and work force (Morrison-Knudsen Engineers, Inc., 1986).

During the first season, the contractor would put in place the stream diversion and cofferdams, excavate and haul to waste the dam foundation common and rock, excavate the abutment gallery tunnels and procure, process and stockpile the aggregates needed for the RCC dam construction. To accomplish this work in the 6 to 7 month season, the contractor would mobilize an excavation spread consisting of a loader, a crawler dozer and ripper, off-highway trucks, and support equipment such as patrols, water wagon, pumps, portable light stands with generators, and a mechanic's truck and fuel truck. The rock work would require two air-track drills and compressors. A powder and separate cap magazine would be needed. An underground diesel and a gas storage tank would also be required.

The aggregate processing operation is envisioned as follows:

- Develop upstream diversion and borrow area drainage.

- Strip borrow area with crawler dozer.

- Pick up aggregate and haul to processing plant using scrapers. The average haul is about 3,500 feet.

- The crushing and screening plant would be set up where the 260,000 cubic yards of required aggregate can be safely stockpiled. The most convenient site is located about 1 mile upstream of the dam on the west side of the valley about 2,000 feet south of the confluence of Shoe and Stocking Creek and Rock Creek.

- Stockpiling would be by highway end dump trucks and front-end loader or crawler dozer.

The screening and borrow haul would be on a double-shift basis, whereas the dam and diversion work would be primarily a single-shift operation.

In the second season, the RCC dam would be constructed and all associated items completed. The diversion scheme would be adequate for a 10-year flood, so that spring runoff would not damage the first year's construction work or negatively impact other resources such as water quality, etc.

The contractor would mobilize and test out his RCC batch plant prior to and during flood stage of Rock Creek. The plant would have a maximum capacity of 200 cu yd per hour, with the average production based on two 10-hour shifts, 6 days per week, of 140 cu yd per hour.

The batch plant may be a conventional batch type with two 4-cu yd tilting mixers or a flow-through pugmill continuous mix type. The plant would be fed by a main conveyor that is, in turn, fed by a large front end loader, working from the three aggregate piles. Each cubic yard of RCC mix would have approximately 135 pounds of cement and 65 pounds of pozzolan (fly ash). Both cement and pozzolan would be trucked to the site by semi-tractors pulling 100 barrel (20 ton) bottom dump hopper trailers. Approximately 8-10 truck deliveries per day of cement and pozzolan would be required for approximately 80 days. The facing and bedding mix would be placed concurrently with the RCC. A separate dry batch transit mix mobile plant would be set up at the RCC batch plant site. The plant would have a capacity of 20 to 25 cu yds per hour. Transit mix trucks would mix and haul the dry batch aggregate and cement to the dam site.

Upon completion of the RCC dam in September (Fig. 2.4.4), the balance of the work, consisting of the precast or poured-in-place training walls, outlet works manifold and control valves, shotcreting of the ogee section of the spillway and top deck structural concrete would be completed. Drilling of grout holes and drainage holes and grouting of dam from the galleries would be one of the last items of work.

The access road would be needed in the first year and should be scheduled as one of the first items of work. The relocation of the transmission line and State Highway 134 and of the old stage coach building could be scheduled for either the first or second season.

2.4.4.3. Construction Schedule. The schedule (Fig. 2.4.4) shows the principal items of work and the timing for the duration of the items, but does not account for potential onsite mitigation activities which may arise. For example, excavation of cultural features uncovered during construction activities could be required.

2.4.4.4. Manpower Estimates and Labor Sources. Referring to the construction schedule, Fig. 2.4.4, the estimate of manpower by month is shown for the 2-year duration. Due to the short season, the principal items of work have been set up on a 2-shift basis for the aggregate production in the first year and on two 10-hour shifts for the roller-compacted concrete embankment the second season. The contractor would probably bring his permanent supervisory personnel with him, plus key or lead operators, master mechanic, and key office personnel. Approximately 60 percent of the labor force, consisting of general laborers, carpenters,

Figure 2.4.4
ROCK CREEK DAM
Construction Schedule

ACTIVITY NOS.	PRINCIPAL ITEM	QUANTITY	UNIT	FIRST YEAR									SECOND YEAR											
				APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
											WINTER SHUTDOWN													
1	ACCESS ROAD	4.8	MI.																					
2	HWY. 134 RELOCATION	0.8	MI.																					
3	TRANS. LINE RELOCATION	3.9	MI.																					
4	STAGE COACH BLDG. RELOCATION		LS.																					
5	DIVERSION & CARE OF STREAM		LS.																					
6	FOUNDATION EXCAVATION	89,000	CY.																					
7	FOUNDATION CLEANUP	8,000	SY.																					
8	RCC PLACEMENT																							
	A. PROCESS AGGREGATE	260,000	CY.																					
	B. SET UP BATCH PLANTS		LS.																					
	C. PLACE RCC	163,200	CY.																					
	D. PLACE FACING & BEDDING MIX	16,900	CY.																					
9	SHOTCRETE SPILLWAY		LS.																					
10	DAM APPURENANCES		LS.																					
11	OUTLET WORKS		LS.																					
12	DRILLING FOR GROUTING	7,600	LF.																					
13	DRILLING FOR DRAINAGE	11,400	LF.																					
14	GROUTING	2,000	LF.																					
	CONTRACTOR'S MANPOWER			5	59	67	84	87	66	20	2	1	0	1	3	13	23	26	100	100	94	42	21	12

and heavy equipment operators may be procured locally. No construction camp is contemplated. Workers other than those who live locally would seek housing or trailer sites in Kremmling, Yampa, and other surrounding communities.

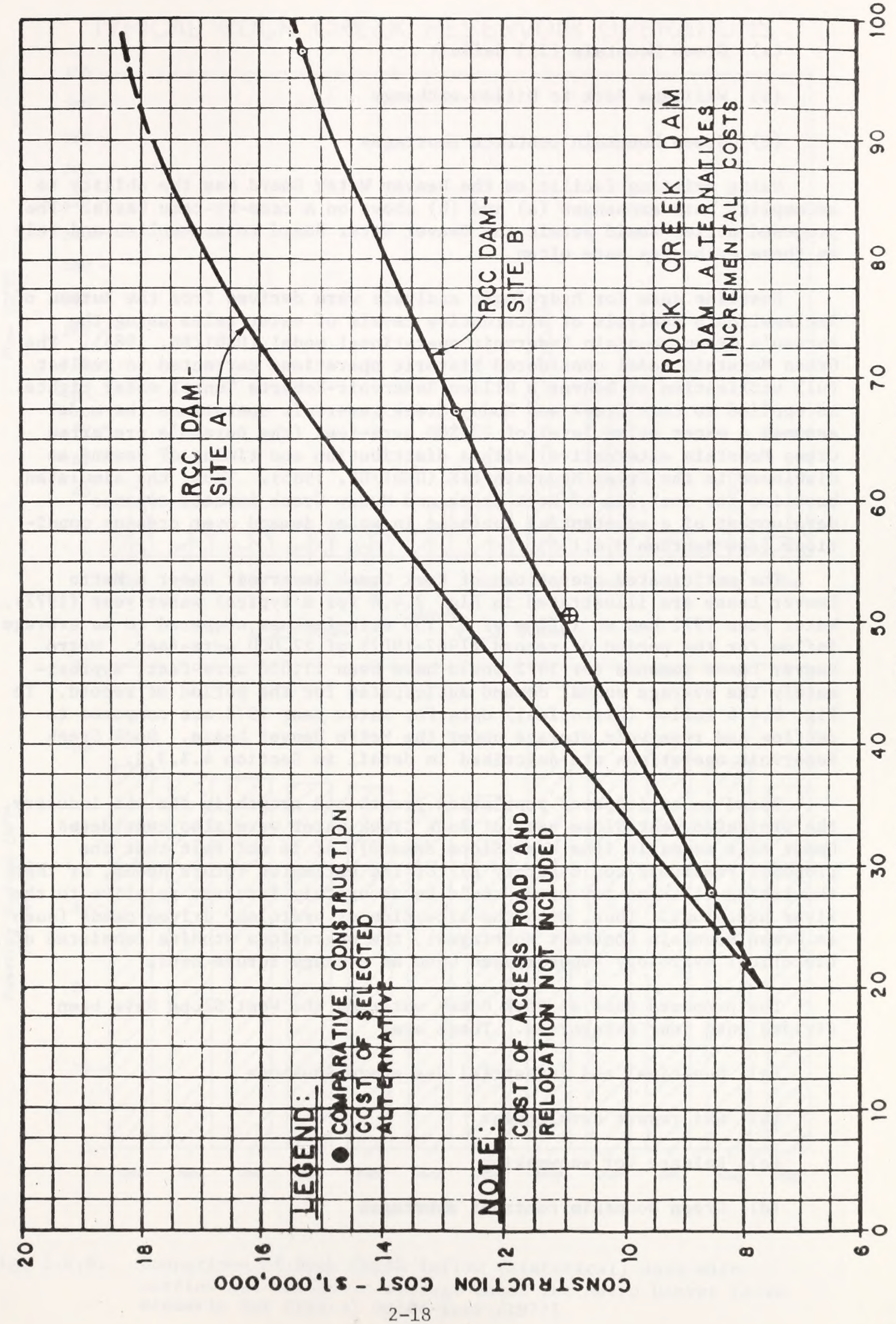
2.4.5. Rock Creek Reservoir, Alternate Damsite Locations. Dam Site A, the alternate damsite on Rock Creek, is located about 3,000 feet upstream of the preferred Dam Site B, and about 700 feet downstream of the mouth of Horse Creek (see Fig. 2.4.1). From an economic and engineering standpoint, this is not as efficient a site to construct a dam (i.e., more concrete is required per foot of height). There would be no differences in the relocations required. The major difference between these two sites is that Site A inundates approximately 3,000 feet less of stream channel. Reconnaissance level construction cost estimates were made for three sizes of dams at both Site A and Site B. These estimates, shown on Figure 2.4.5, show that a dam built at Site A (upstream site) would cost about 10 percent more and impound about 10 percent less water than a dam built to the same elevation at Site B (downstream site); therefore, the cost per unit of storage is more than 20 percent higher at Site A.

2.4.6. Non-Federal Land Acquisition. With the exception of approximately 100 acres of private land at the upper end of the proposed Rock Creek Reservoir and approximately 200 acres of State land along Rock Creek, all of the reservoir basin lies on National Forest System lands. The private land would be purchased by the River District. The Forest Service would require the River District to deed this land to the United States. The 200 acres of State land along Rock Creek in the basin would be acquired by the River District.

2.4.7. Rock Creek Reservoir Operations Summary. Under Colorado's system of water law, those water users with the most senior priority dates get the first call on available water. For this reach of the Colorado River, the senior water rights at Cameo (collectively about 2200 cfs with pre-1920 priority dates) or Shoshone Power Plant (about 1250 cfs with a priority date of 1902) control the administration of the river. Diversions junior to the Shoshone and Cameo rights need to provide augmentation water for periods when their junior right is "out of priority." Thus, Rock Creek would be primarily a source of augmentation water.

Although intended to serve West Slope interests, water from a reservoir at Rock Creek would be marketed to the Denver Water Board (Metro Denver Lease) in the short term (25 years). This short-term operational scenario was formalized under the December 1986 Denver Water Board - River District Agreement (see Section 1.3.6). Under this scenario, Rock Creek water would be used to exchange water upstream to Denver Water Board diversions, removing part of the call on Dillon Reservoir by Green Mountain Reservoir. Rock Creek water could also be used to allow Denver to divert water by exchange at Dillon Reservoir or its other diversion facilities, make up Green Mountain contract shortages, or firm up Middle Park Water Conservancy District's rights in Granby Reservoir. Thus, three categories of water use are identified under the Metro Denver Lease:

FIGURE 2.4.5


ROCK CREEK DAM
DAM ALTERNATIVES
INCREMENTAL COSTS
RCC DAM-
SITE A
RCC DAM-
SITE B
LEGEND:
● COMPARATIVE CONSTRUCTION COST OF SELECTED ALTERNATIVE
NOTE:
COST OF ACCESS ROAD AND RELOCATION NOT INCLUDED
RESERVOIR STORAGE - 1000 AC. FT.
0
10
20
30
40
50
60
70
80
90
100
CONSTRUCTION COST - $1,000,000
20
18
16
14
12
10
8
6

(a) Green Mountain fill deficit

(b) Williams Fork to Dillon exchange

(c) Green Mountain contract shortages

Using existing facilities the Denver Water Board has the ability to accomplish both exchanges (a) and (b) above on a case-by-case basis. The proposed action would permit the Denver Water Board to accomplish and rely on these exchanges more often.

Baseline data for hydrologic analysis were derived from the Bureau of Reclamation's analysis of alternative levels of water sales using the Bureau's Green Mountain Reservoir operational model (USDI/BR, 1985). The Green Mountain model considered historic operations corrected to reflect full utilization of Denver's Dillon Reservoir-Roberts Tunnel water rights. As applied to Rock Creek and Muddy Creek reservoir operations the model assumes a water sales level of 22,800 acre-feet (the Bureau's preferred Green Mountain alternative) with a distribution and timing of demand as disclosed in the Green Mountain EIS (USDI/BR, 1985). Thus, the simulated baseline for analysis of Rock Creek and Muddy Creek impacts assumes development of a substantial increase in water demand over present conditions (see Section 3.4.1.3).

The anticipated operations of Rock Creek Reservoir under a Metro Denver Lease are illustrated in Fig. 2.4.6 for a typical water year (1972). Water year 1972 had an inflow of 25,130 acre-feet as compared to an average inflow for the period of record (1962-1982) of 27,000 acre-feet. Metro Denver Lease demands for 1972 would have been 11,050 acre-feet, approximately the average annual demand anticipated for the period of record. In Fig. 2.4.6 inflow (historical) data for water year 1972 are compared to outflow and reservoir storage under the Metro Denver Lease. Rock Creek Reservoir operations are described in detail in Section 4.3.3.3.

Based on anticipated population growth and growth in the ski industry, the projected West Slope uses of Rock Creek water were also considered. Under this scenario (the West Slope demand), it is not felt that the proposed reservoir could supply all of the estimated future needs, or that the timing of these new needs could be accurately forecast relative to the river hydrology. Thus, with the exception of hydrology driven needs (such as Green Mountain Contract shortages), the operations studies consisted of historical hydrology superimposed upon an average future need.

The proposed uses of Rock Creek water on the West Slope have been divided into four categories. These are:

(a) Municipal and industrial use above Shoshone

(b) Ski resort development

(c) Release for snowmaking

(d) Green Mountain contract shortages

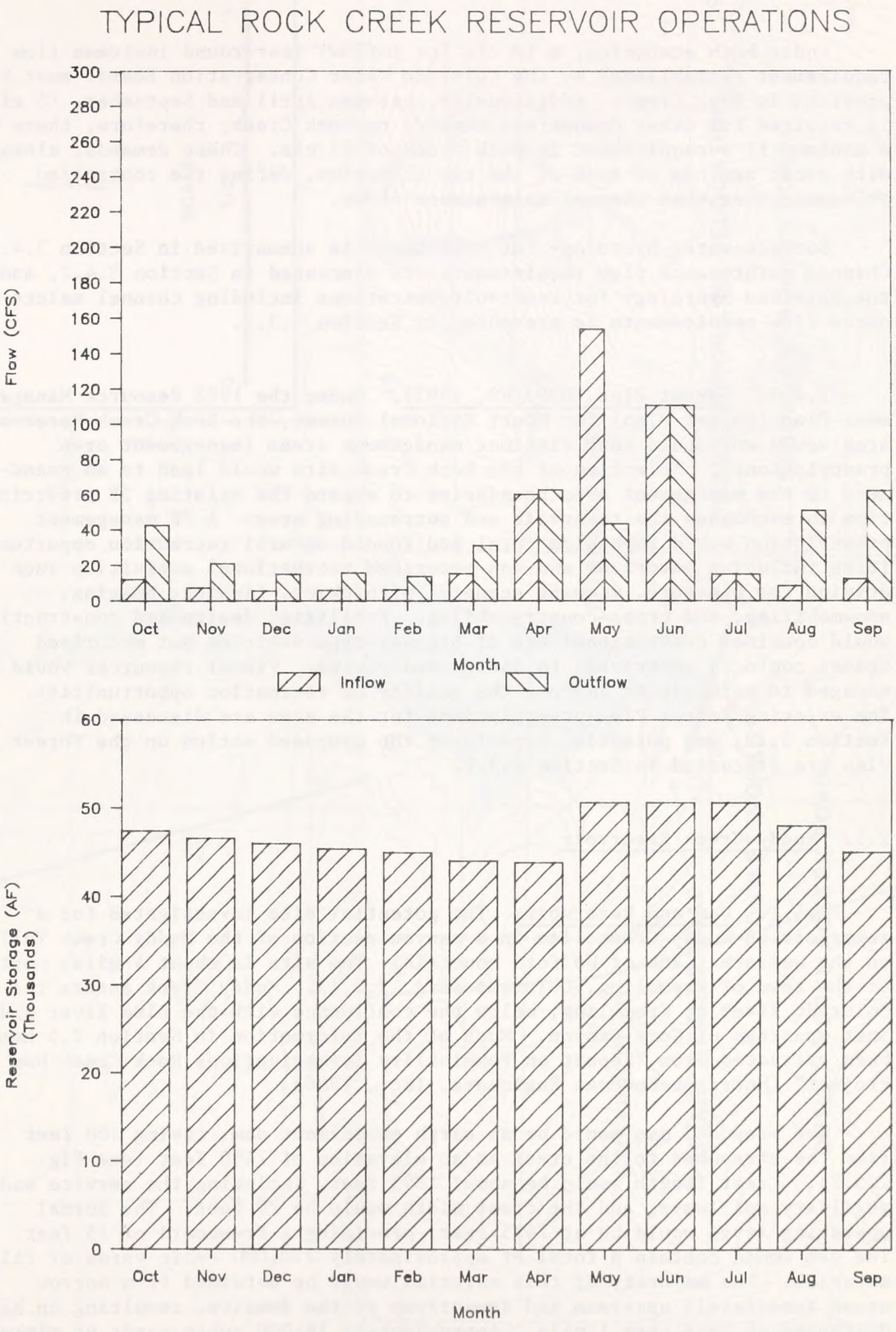


Fig. 2.4.6. Comparison of Rock Creek inflow (historical) data with outflow and reservoir storage under the Metro Denver Lease scenario for typical water year (1972).

Under both scenarios, a 10 cfs (or inflow) year-round instream flow requirement (established by the Colorado Water Conservation Board) must be provided in Rock Creek. Additionally, between April and September, 15 cfs is required for other downstream demands on Rock Creek; therefore, there is a minimum flow requirement in Rock Creek of 25 cfs. These demands, along with other demands of each of the two scenarios, define the controlled releases other than channel maintenance flows.

Surface-water hydrology for Rock Creek is summarized in Section 3.4.1. Channel maintenance flow requirements are discussed in Section 3.4.2, and the detailed hydrology for reservoir operations including channel maintenance flow requirements is presented in Section 4.3.3.

2.4.8. Forest Plan (USDA/FS, 1983). Under the 1983 Resource Management Plan (Forest Plan) for Routt National Forest, the Rock Creek Reservoir area would encompass four distinct management areas (management area prescriptions). Selection of the Rock Creek site would lead to an amendment to the management area boundaries to expand the existing 2B prescription to encompass the reservoir and surrounding area. A 2B management prescription would emphasize rural and roaded natural recreation opportunities including motorized and non-motorized recreational activities such as driving for pleasure, viewing scenery, picnicking, fishing, boating, snowmobiling, and cross-country skiing. Facilities design and construction would consider conventional use of highway-type vehicles but motorized travel could be restricted to designated routes. Visual resources would be managed to maintain or improve the quality of recreation opportunities. The existing Forest Plan prescriptions for the area are discussed in Section 3.10, and potential impacts of the proposed action on the Forest Plan are discussed in Section 4.3.9.

2.5. Muddy Creek Reservoir

2.5.1. Dam and Reservoir. The potential site investigated for a reservoir on Muddy Creek lies in a canyon section of the Muddy Creek Valley on the western flank of Wolford Mountain. The site is about 4 miles north of the town of Kremmling, Colorado (Fig. 2.5.1). Muddy Creek enters the Colorado River at Kremmling, below the confluence with the Blue River and just upstream of Gore Canyon. Much of the information in Section 2.5 has been extracted from "Report on Feasibility Investigations Rock Creek Dam Project" (Morrison-Knudsen Engineers, Inc., 1986).

The proposed dam would be an earth embankment dam, rising 108 feet from the streambed to the crest at an elevation of 7490 feet (see Fig. 2.5.2). Crest length would be about 1895 feet, including the service and auxiliary spillways, and the crest width would be 20 feet. The normal operating level would be at 7475 feet, providing a freeboard of 15 feet. The dam would contain a total of approximately 270,000 cubic yards of fill material. The majority of this material would be obtained from borrow areas immediately upstream and downstream of the damsite, resulting in haul distances of less than 1 mile. Approximately 18,000 cubic yards of riprap would have to be hauled 40 miles from a quarry to the east, and a supplier in Kremmling may supply up to 78,000 cubic yards of filter material.

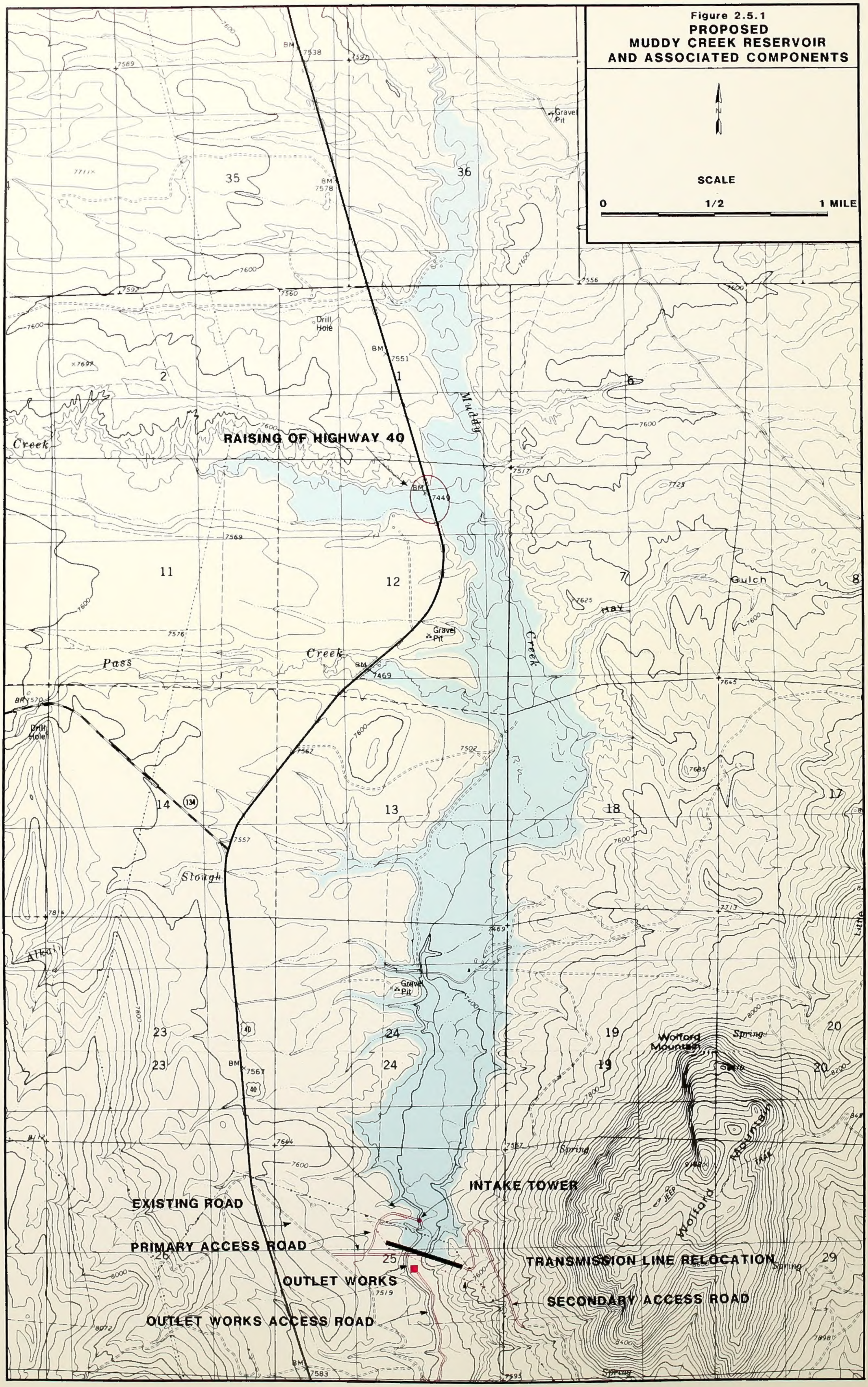


Figure 2.5.1
PROPOSED
MUDDY CREEK RESERVOIR
AND ASSOCIATED COMPONENTS
N
SCALE
0
1/2
1 MILE
RAISING OF HIGHWAY 40
INTAKE TOWER
EXISTING ROAD
PRIMARY ACCESS ROAD
TRANSMISSION LINE RELOCATION
OUTLET WORKS
SECONDARY ACCESS ROAD
OUTLET WORKS ACCESS ROAD
Muddy Creek
Pass Creek
Hay Gulch
Slough
Alkali
Wolford Mountain
Gravel Pit
Drill Hole

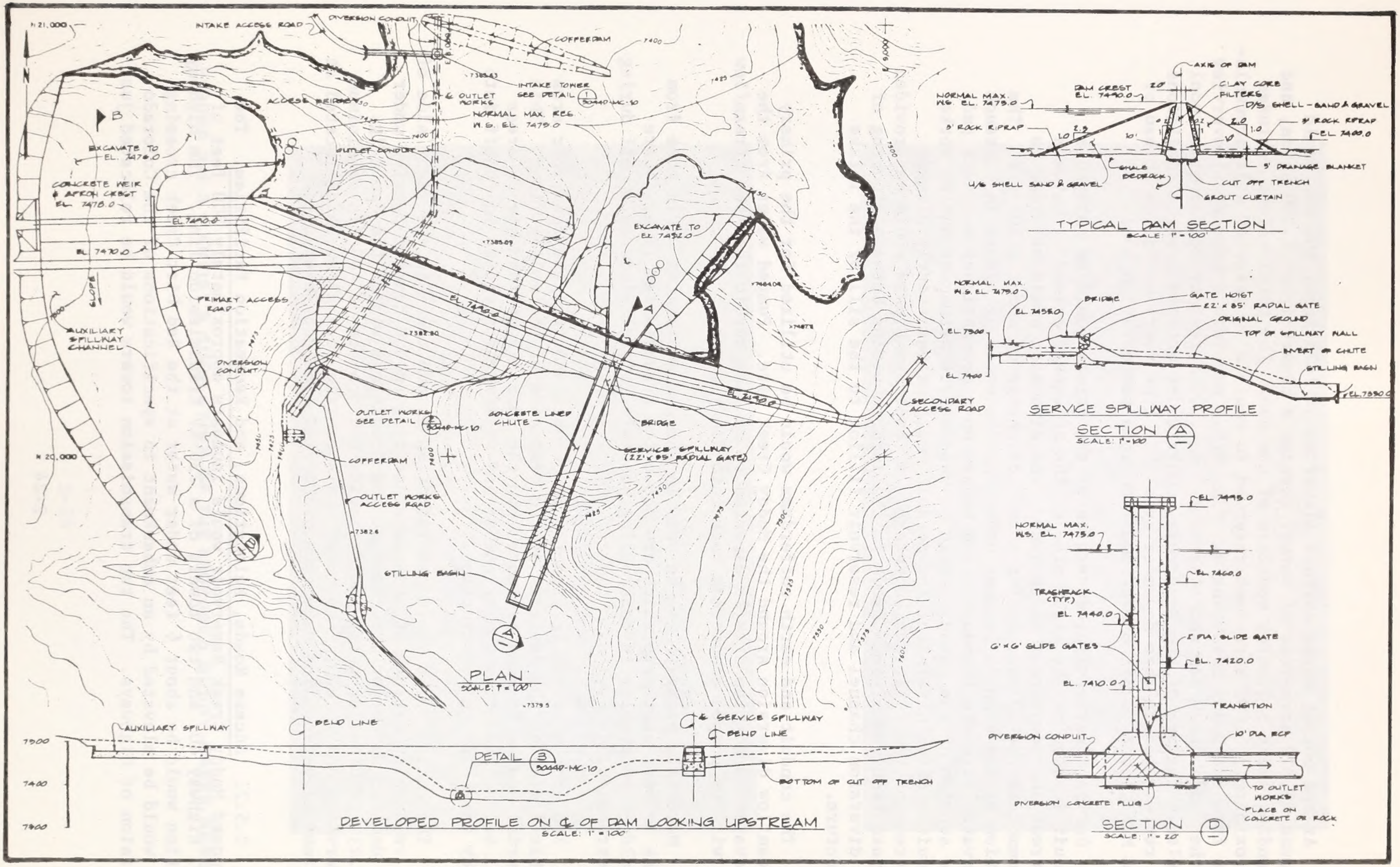


FIGURE 2.5.2 MUDDY CREEK DAM ELEVATIONS and OUTLET WORKS
Source: MORRISON KNUDSEN ENGINEERING, INC.

At the normal water surface elevation of 7475 feet, the dam would impound 46,800 acre-feet of water, forming a reservoir of 1,200 acres, and extending about 5.3 miles upstream of the dam. The total volume includes approximately 6,000 acre-feet reserved to contain 50 years of silt accumulation from the Muddy Creek basin. Fig. 2.5.3 provides a conceptual overview of the Muddy Creek dam and reservoir. A 4,000 acre-foot conservation pool is also a feature of the reservoir. Only under extreme drought conditions (as represented in this document by a 1977 type year) would the Bureau of Land Management permit encroachment on this conservation pool.

During construction, diversion of the stream would be through a conduit located on the right side of the streambed extending between upstream and downstream cofferdams. The diversion would be sized to accommodate the 10-year spring runoff discharge of about 1,500 cfs. The portion of the conduit passing under the dam would be placed in a trench excavated into the foundation and bedded on a conventional concrete pad. This section of the conduit would be used as the permanent outlet works conduit. After diversion, the conduit would be permanently plugged upstream of the outlet works intake. A temporary bypass would be provided to pass required minimum flows in the interim period between plugging of the diversion channel and reservoir filling to the sill of the intake structure.

The conduit and earth cofferdams would be utilized for the primary streamflow diversion around the Muddy Creek site. Pumped water from the excavated foundation area is expected to be less turbid than the streamflow and will be pumped downstream back into Muddy Creek.

Materials excavated to be used in the dam embankment would come from areas on both abutments which are above the ground-water line. There should be no problem in controlling possible rainfall-induced runoff during construction.

The core material is expected to be obtained from the reservoir area within 1 mile of the dam axis at the west side of the valley floor. This material source is some distance from the main channel and borrow areas will be isolated from the streambed and will not contribute to runoff into Muddy Creek during construction.

The outlet works would consist of an intake tower in the right side of the reservoir upstream of the dam connecting to the conduit passing under the dam and an outlet structure at the downstream toe of the dam (Fig. 2.5.2). The outlet works would provide a discharge of 400 cfs at minimum reservoir pool. The intake tower would contain four slide gates located at various elevations for selective withdrawal from the reservoir.

2.5.2. Access Roads, Relocations, and Recreation Facilities. The proposed Muddy Creek Reservoir would inundate approximately 800 feet of U.S. Highway 40, and two towers of a 230-kV transmission line. The highway section would be about 6 feet under water at the Red Dirt Creek crossing and would be elevated by an embankment to specifications of the Colorado Division of Highways. The two transmission towers would be relocated just

FIGURE 2.5.3 - ARTIST'S SIMULATION OF THE PROPOSED MUDDY CREEK RESERVOIR.

downstream of the dam. Primary access to the dam would consist of a turnoff from U.S. Highway 40 approximately 3 miles north of the town of Kremmling. This primary access road would lead to the dam crest after crossing the auxiliary spillway and would thus be out of service during extreme flooding events. Consequently, a secondary access road would be planned (Fig. 2.5.1) as a continuation of the transmission line road on the eastern side of the reservoir. There would also be secondary access roads from the west side to the outlet works at the toe of the dam and to the outlet tower within the reservoir.

The Bureau of Land Management would require development of a recreation plan for the reservoir. This plan would include consideration of a day use site and boat ramp on the west side of the reservoir to be developed by the River District. In addition, as recreation demand develops, additional facilities may be necessary. The facilities could be provided and managed by concessionaires. The plan would also address a management and recreation buffer strip around the reservoir and measures to control dispersed recreational use of the facility.

2.5.3. Operating Facilities and Project Administration. The operation, maintenance, and repair of the dam, outlet works, spillway, and other appurtenances would be the responsibility of the River District.

2.5.4. Muddy Creek Construction Planning and Schedule

2.5.4.1. Materials Sources. Impervious materials for the core would be borrowed from areas upstream from the dam on the right bank, within a half-mile haul. Allowing for stripping of organic material and shrinkage of the impervious core materials, 212,000 cu yd would be handled to produce 154,000 cu yd of in-place core. The shell material for the upstream and downstream reaches would be borrowed from the left bank immediately downstream from the damsite and a little south of the planned spillway chute. It is possible that materials from the dam foundation excavation, spillway chute, and emergency spillway sections would all produce satisfactory shell material.

The remaining portions of the dam embankment consist of the filter blanket, 78,000 cu yd; blanket drain, 20,000 cu yd; and riprap, 17,800 cu yd. The filter materials might possibly be procured from the downstream borrow area or the spillway chute excavation with screening and processing necessary to meet the specification. Concrete and filter material could be produced onsite or procured locally from a commercial source. There is no known source of riprap available within the Kremmling area. At present construction planning contemplates a quarry source to the east, within a 40-mile haul limit.

Dam foundation excavation would be waste stockpiled upstream from the dam site, probably within a half-mile haul. This material, if satisfactory for shell material, would be hauled back to the dam in lieu of the downstream borrow.

2.5.4.2. Contractor's Plant and Operations. Specialized equipment would not be required for the earthwork phases of construction. Material would be moved by scrapers and conventional compaction equipment or by front-end loader and off-highway trucks, depending upon what equipment may be available to the successful contractor at the time the work would be performed.

The total excavation is approximately 570,000 cu yd for the dam foundation, outlet works and spillway structure. Embankment borrow for the impervious core would total another 650,000 cu yd excluding the filter zones and blanket drain. The total common excavation, therefore, including the shale for the cutoff trench would approximate 1,200,000 cu yd. This excavation could be performed by push cats with rippers, 21 cu yd single-engine scrapers and support equipment for haul road maintenance (patrol and water truck). Embankment compaction equipment would consist of a cat-drawn sheepsfoot roller, a vibrating smooth-wheel double-drum roller, water trucks for moisture control, patrol, and a hand compaction crew for difficult compaction reaches.

This equipment could construct the dam in one working season if the weather were favorable, a notice to proceed were issued in early March, and stream diversion flow were to fall within a 10-year flood forecast. Total concrete required for the structures would be less than 9,000 cu yd, which, if performed in one season, would require peak placements of 500 cu yd per week. Planning for a two-season cycle is a more conservative approach.

2.5.4.3. Construction Schedule. The construction schedule (Fig. 2.5.4) shows the principal items of work and the sequence of activities based on a two-season approach. The schedule does not account for potential onsite mitigation activities which may arise. For example, excavation of cultural features uncovered during construction activities could be required. During the first year, the diversion of the stream would be accomplished with the upstream and downstream cofferdams, the foundation excavation and the drilling and foundation grouting completed. The inlet tower and outlet stilling basin would be constructed. Depending upon overall progress, the dam embankment would probably be constructed up to the original streambed before winter shutdown. Some temporary riprap and gravel bedding would be placed over the embankment constructed up to streambed level to protect against possible flood damage.

After the runoff peak in the spring, the balance of the dam embankment, the spillway chute, and the emergency spillway would be constructed and the riprap placed.

2.5.4.4. Manpower Estimate and Labor Sources. The estimate of manpower by month is shown for the 2-year duration on Fig. 2.5.4. The contractor would probably bring his permanent supervisory personnel with him, plus key or lead operators, master mechanic, and key office personnel. Approximately 60 percent of the labor force, consisting of general laborers, carpenters, and heavy equipment operators may be procured locally. No construction camp is contemplated. Workers other than those who live locally would seek housing or trailer sites in Kremmling and other surrounding communities.

Figure 2.5.4

MUDDY CREEK DAM
Construction Schedule

ACTIVITY MOS.	PRINCIPAL ITEM	QUANTITY	UNIT	FIRST YEAR										SECOND YEAR										
				MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
											WINTER SHUTDOWN													
1	ACCESS ROADS	3.6	MI.																					
2	MODIFICATION HWY. 40		LS.																					
3	TRANS. LINE RELOCATION	0.75	MI.																					
4	DIVERSION & CARE OF STREAM		LS.																					
5	DAM FOUNDATION EXCAVATION	291,000	CY.																					
6	CORE TRENCH EXCAVATION	30,200	CY.																					
7	GROUT CAP CUT OFF	1,900	LF.																					
8	DRILLING & GROUTING		LS.																					
9	CONSTRUCTION DAM EMBANKMENT																							
	A. CORE TRENCH PREP.	12,000	SY.																					
	B. PLACE IMPERVIOUS CORE	154,000	CY.																					
	C. PLACE FILTER	78,000	CY.																					
	D. PLACE BLANKET DRAIN	20,000	CY.																					
	E. PLACE SAND & GRAVEL SHELL	410,000	CY.																					
	F. PLACE RIPRAP	17,800	CY.								+ +													
10	OUTLET WORKS																							
	A. FURN. & INST. 10' RCP	800	LF.																					
	B. CONSTRUCT INTAKE TOWER	2,500	CY.																					
	C. CONSTRUCT OUTLET STRUCTURE		LS.																					
11	SPILLWAY CONSTRUCTION																							
	A. EXCAVATION	242,000	CY.																					
	B. SPILLWAY CONCRETE	5,500	CY.																					
	C. SET GATE		LS.																					
	+ + TEMPORARY PROTECTION																							
	CONTRACTORS MANPOWER			8	33	48	89	78	77	85	83	3	0	0	0	3	35	84	108	129	103	20	3	

2.5.5. Muddy Creek Reservoir Alternative Damsite Locations. A damsite (Muddy "A") directly above the town of Kremmling was considered during the early phases of the study. It was removed from further consideration due to concern with its proximity to the Antelope Pass Thrust Fault and the cost associated with its construction (see Section 2.2.2.3). It is possible that the dam axis shown in Fig. 2.5.1 could be moved up to a quarter of a mile downstream during final site selection and design if the Muddy Creek alternative were selected.

2.5.6. Private Land Acquisition. Muddy Creek site C lies on public land administered by the Bureau of Land Management land, but much of the reservoir basin is in the private ownership of three ranches. The private lands in and surrounding the reservoir basin consist of about 2½ sections or 1,600 acres. Although not all of these lands would be inundated by the proposed project, it is anticipated that they would all be acquired by the River District to ensure equitable treatment of the landowners. Otherwise, there would be small, isolated parcels of private land, an undesirable situation for both the landowner and the reservoir operator. It is expected that these lands would provide potential concessionaire opportunities for recreation facilities.

2.5.7. Muddy Creek Reservoir Operations Summary. Muddy Creek Reservoir operations would include the same Denver Metro Lease and West Slope demand scenarios as described for Rock Creek Reservoir in Section 2.4.7. As with Rock Creek, Muddy Creek Reservoir would be primarily a source of augmentation water. There are presently no Colorado Water Conservation Board instream flow requirements on Muddy Creek; however, Muddy Creek Reservoir operational analysis has assumed a 13 cfs minimum flow below the proposed dam. The anticipated operations of Muddy Creek Reservoir under a Metro Denver Lease are illustrated in Fig. 2.5.5 for a typical water year (1972). Water year 1972 had an inflow of 68,000 acre-feet, approximately the average annual inflow for the period of record (1962-1982). Metro Denver Lease demands for 1972 would have been 11,050 acre-feet, approximately the average annual demand anticipated for the period of record. In Fig. 2.5.5 inflow (historical) data for water year 1972 are compared to outflow and reservoir storage under the Metro Denver Lease. Muddy Creek Reservoir operations are described in detail in Section 4.4.3.3. Surface-water hydrology for Muddy Creek is summarized in Section 3.4.1 and the detailed hydrology for reservoir operations is presented in Section 4.4.3.

2.5.8. Resource Management Plan. In the 1984 Kremmling Resource Management Plan Record of Decision, the BLM lists livestock grazing as the priority land use for the Muddy Creek Reservoir area. Under this category of land use livestock grazing priority areas would be committed to the production of livestock forage and grazing for livestock. Grazing and range management would be the priority use. However, the Record of Decision lists other compatible uses including major realty actions (provided the actions do not interfere significantly with livestock grazing). Selection of the Muddy Creek site would be viewed by the BLM as a compatible use, however, an amendment may be required to address specific changes. Existing land use for the area is described in Section 3.10 and potential impacts are discussed in Section 4.4.9.

TYPICAL MUDDY CREEK RESERVOIR OPERATION

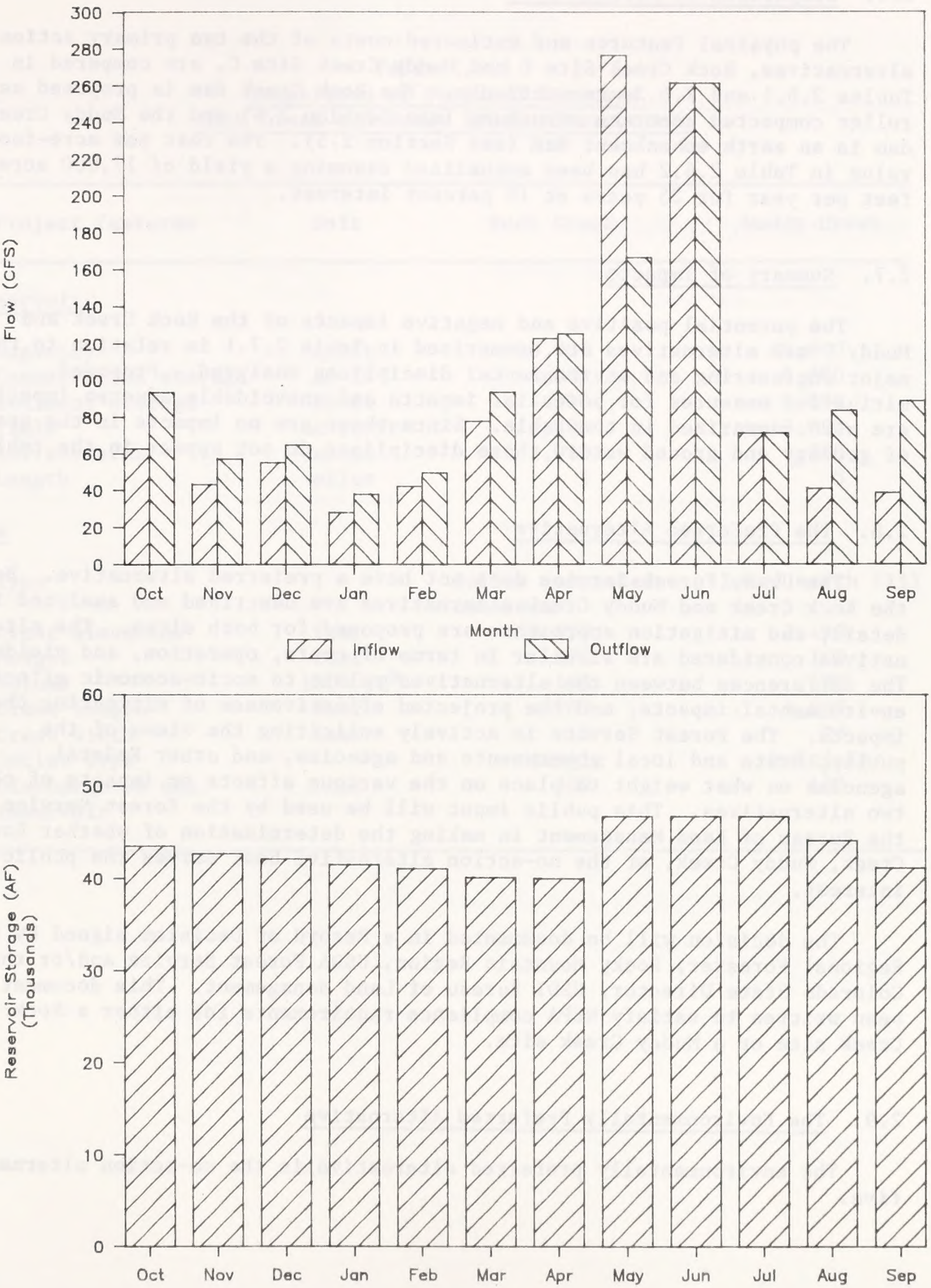


Fig. 2.5.5. Comparison of inflow (historical) data with outflow and reservoir storage under the Metro Denver Lease scenario for typical water year (1972)--Muddy Creek.

2.6. Comparison of Alternatives

The physical features and estimated costs of the two primary action alternatives, Rock Creek Site B and Muddy Creek Site C, are compared in Tables 2.6.1 and 2.6.2, respectively. The Rock Creek dam is proposed as a roller compacted concrete structure (see Section 2.4) and the Muddy Creek dam is an earth embankment dam (see Section 2.5). The cost per acre-foot value in Table 2.6.2 has been annualized assuming a yield of 17,000 acre-feet per year for 25 years at 10 percent interest.

2.7. Summary of Impacts

The potential positive and negative impacts of the Rock Creek and Muddy Creek alternatives are summarized in Table 2.7.1 in relation to the major engineering and environmental disciplines analyzed. Proposed mitigation measures for potential impacts and unavoidable adverse impacts are also summarized in the table. Since there are no impacts in the areas of geology and ground water, these disciplines do not appear in the table.

2.8. The Preferred Alternative

The U. S. Forest Service does not have a preferred alternative. Both the Rock Creek and Muddy Creek alternatives are described and analyzed in detail, and mitigation approaches are proposed for both sites. The alternatives considered are sismilar in terms of costs, operation, and yields. The differences between the alternatives relate to socio-economic effects, environmental impacts, and the projected effectiveness of mitigating these impacts. The Forest Service is actively soliciting the views of the public, State and local governments and agencies, and other Federal agencies on what weight to place on the various effects or impacts of the two alternatives. This public imput will be used by the Forest Service and the Bureau of Land Management in making the determination of whether Rock Creek, Muddy Creek, or the no-action alternative best serves the public interest.

The decision will be documented in a Record of Decision signed by the Regional Forester, Rocky Mountain Region, USDA Forest Service and/or the Colorado State Director, USDI Bureau of Land Management. This document has been written to satisfy NEPA compliance requirements for either a Rock Creek site or a Muddy Creek site.

2.9. The Environmentally Preferred Alternative

The environmentally preferred alternative is the no-action alternative.

Table 2.6.1
Comparison of Physical Features
Rock Creek and Muddy Creek Alternatives

Project features	Unit	Rock Creek	Muddy Creek
Reservoir			
Capacity	ac-ft	50,700	46,800
Conservation storage	ac-ft	4,000	4,000
Sediment storage	ac-ft	500	6,000
Yield	ac-ft/yr	17,000	17,000
Surface area	acres	1,070	1,200
Length	miles	3	5
Dam			
Type	-	Roller compacted concrete	Zoned earth fill
Crest elevation	feet	8,690	7,490
Height	feet	172	110
Volume	1000 yd^3	180	680
Crest length	feet	707	1,895
Crest width	feet	16	20
Outlet type	-	Single	Multiple
Discharge at min. reservoir	cfs	300	400

Table 2.6.2
Comparison of Costs
Rock Creek and Muddy Creek Alternatives

Item	Rock Creek	Muddy Creek
Engineering and Permitting		
Design, permit and management	$2,773,000	$2,811,000
Land acquisition	110,000	1,600,000
Mitigation	1,622,000	1,207,800
Subtotal	4,505,000	5,618,000
Site Cost		
Highway relocation	450,000	740,000
Other (Powerline and historic site relocation, campground)	642,000	350,000
Subtotal	1,092,000	1,090,000
Dam Construction		
Dam and facilities	10,564,000	10,944,000
Contingency	1,748,000	1,805,000
TOTAL PROJECT COST	$17,909,000	$19,457,800
COST PER ACRE-FOOT/YEAR (annualized)	$ 122	$ 132
Annual Operation and Maintenance	$ 100,000	$ 100,000

Table 2.7.1
Rock Creek/Muddy Creek Alternatives
Summary of Potential Positive and Negative Environmental
Impacts, Mitigation Measures, and Unavoidable Adverse Impacts

	Reservoir Site	Soils	Surface Water	Water Quality
POTENTIAL IMPACTS	Rock Creek	1. 3.5 mi. or 18% shoreline unsuitable for recreation. 2. Increased erosion in areas where construction involves disturbance of soil left in place.	1. Channel stability concerns. 2. Risk of dam failure to McCoy.	None
	Muddy Creek Site C	1. Loss of 744 ac. farmland. 2. 12 mi. or 49% of shoreline not suited for recreation. 3. Increased erosion in areas where construction involves disturbance of soil left in place.	1. Possible beneficial change in channel shape. 2. Risk of dam failure to Kremmling.	1. Potential eutrophication and turbidity in reservoir.
MITIGATION	Rock Creek	1. No practical mitigation. 2. Implement site-specific plan for runoff, erosion, and sedimentation control. Implement revegetation plan.	1. Channel maintenance flow used in reservoir release schedule. 2. Inspection, monitoring, and emergency plan required by State Engr.	None
	Muddy Creek	1. Purchase of affected farmlands would mitigate econ. losses, but farmlands could not be replaced. 2. No practical mitigation. 3. Implement site-specific plan for runoff, erosion, and sedimentation control. Implement reveg. plan.	1. No mitigation required. 2. Inspection, monitoring, and emergency plan required by State Engr.	1. Monitoring and modeling during design and early years of operation.
UNAVOIDABLE ADVERSE IMPACTS	Rock Creek	None	None	None
	Muddy Creek	Loss of farmlands of State or local importance.	None	Potential problems with chemical and physical integrity of reservoir.

Table 2.7.1 (continued)
Rock Creek/Muddy Creek Alternatives
Summary of Potential Positive and Negative Environmental Impacts, Mitigation Measures, and Unavoidable Adverse Impacts

	Reservoir Site	Air Quality	Vegetation	Land Use Plans
POTENTIAL IMPACTS	Rock Creek	1. Short-term impacts during construction.	1. 486 ac. of high quality wetlands lost.	1. Inundation of 805 ac. USFS land, 191 ac. CDOW land, and 74 ac. private land. 2. Amendment to Forest Plan required.
	Muddy Creek Site C	1. Potential for increased fogs. 2. Short-term impacts during construction.	1. Loss of 207 ac. of native wetlands and 450 ac. man-affected wetlands. 2. Possible impact to Federal candidate endangered plant.	1. Inundation of 292 ac. BLM land and 908 ac. private land. 2. Amendment to Resource Management Plan required.
MITIGATION	Rock Creek	1. Use of mufflers, filters and dust control techniques during construction.	1. Replacement-in-kind of value of wetlands by creation of new wetlands and rehab. of existing wetlands in poor condition on Egeria Creek.	1. Compensate private landowner for economic loss. 2. Amend Forest Plan.
	Muddy Creek	1. No practical mitigation. 2. Use of mufflers, filters and dust control techniques during construction.	1. Replacement-in-kind of value of wetlands by creation of new wetlands and rehab. of existing wetlands in poor condition. on lower Muddy Creek and adjacent to the reservoir. 2. Fencing of areas containing the Federal candidate plant to prevent trampling, and transplanting or diking to prevent inundation.	1. Compensate private landowner for economic loss. 2. Amend Resource Management Plan
UNAVOIDABLE ADVERSE IMPACTS	Rock Creek	None	None	Inundation of 1070 ac. would eliminate existing land use.
	Muddy Creek	None	A portion of possible impact to the Federal candidate plant may remain.	Inundation of 1200 ac. would eliminate existing land use.

Table 2.7.1 (continued)
Rock Creek/Muddy Creek Alternatives
Summary of Potential Positive and Negative Environmental
Impacts, Mitigation Measures, and Unavoidable Adverse Impacts

	Reservoir Site	Aquatic Biology	Wildlife
POTENTIAL IMPACTS	Rock Creek	1. Loss of 9 mi. of high quality trout stream. 2. Loss of self-sustaining brown trout population below the dam. 3. Opportunity for low to moderate reservoir fishery.	1. Loss of 486 ac. wetland habitat and 1086 ac. non-forested habitat and assoc. wildlife values. 2. Disturbance and loss of habitat reduce habitat capability in area surrounding reservoir. 3. Possibility of migrating elk breaking through ice.
	Muddy Creek Site C	1. Potential for moderate fishery in reservoir and creation of a tailwater fishery downstream.	1. Loss of about 1300 ac. big game winter range in various categories. 2. Loss of 811 ac. wetland habitat and assoc. wildlife values. Possible auto-big game collisions on Hwy 40. 3. Adverse impact to daily and annual big game movement. Possibility of migrating elk breaking through ice.
MITIGATION	Rock Creek	1. Rehab. of Egeria Cr. site would mitigate a portion of the loss, but would not replace all aquatic resource values lost. 2. Monitoring of reproduction and stocking to maintain a fishable resource. 3. No mitigation required.	1. Replace lost HUs with land with appropriate habitat potential. 2. Forest Service will enforce restrictions on vehicular use off road. 3. Monitor big game populations during migration and provide fencing, if needed.
	Muddy Creek	1. No mitigation required.	1. Enhance carrying capacity in big game range; attract game to improved areas. 2. Replace lost HUs by acquiring appropriate private land. Better management of public lands for wildlife values. Signs on Highway 40 warning of big game. 3. Monitor big game populations during migration and provide fencing, if needed.
UNAVOIDABLE ADVERSE IMPACTS	Rock Creek	A portion of loss of high quality habitat in reservoir basin. A portion of loss of self-sustaining brown trout population below dam.	Some disturbance and loss of habitat capability not mitigated, but overall population numbers would not be reduced.
	Muddy Creek	None	None

Table 2.7.1 (continued)
Rock Creek/Muddy Creek Alternatives
Summary of Potential Positive and Negative Environmental
Impacts, Mitigation Measures, and Unavoidable Adverse Impacts

		Grazing	Visual Resources	Recreation Resources
POTENTIAL IMPACTS	Rock Creek	1. Potential 11% loss of carrying capacity (AUMs) to one allotment.	1. Dam would exceed amended Forest Plan VQO for the area. 2. Reservoir would exceed amended VQO for area for 2-3 years after extreme dry periods.	1. Loss of trout stream. 2. Loss of historic stage stop. 3. Gain in 200,000 recreation visitor-days to reservoir and facilities to support visitation. 4. Offsite development.
	Muddy Creek Site C	1. Loss of 2043 AUM's on private land.	1. Some impacts from dam access road and downstream material site. 2. Reservoir would exceed VRM for area for 1 year after extreme dry periods.	1. Gain of 175,000 recreation visitor-days to reservoir and a recreation facility. 2. Private and offsite development. 3. Development of tailwater fishing.
MITIGATION	Rock Creek	1. Replace AUMs by purchase of private land, or range improvement to increase carrying capacity of remainder of allotment.	1. Amend Forest Plan. 2. Amend Forest Plan.	1. Development of fishery at Egeria Cr. would partially mitigate loss. 2. Relocate historic stage stop or catalogue and inundate. 3. No mitigation required. 4. No mitigation planned.
	Muddy Creek	1. Purchase private lands with purchase price compensating for forage loss.	1. Grading, sloping, contouring, and revegetation of material site and roadcut. 2. Amend Resource Management Plan.	1. No mitigation required. 2. No mitigation planned. 3. No mitigation planned.
UNAVOIDABLE ADVERSE IMPACTS	Rock Creek	None	Amended VQO for area exceeded for 2-3 years after extreme dry periods.	Loss of fishery would not be totally mitigated.
	Muddy Creek	None	VRM for area exceeded for 1 year after extreme dry periods.	None.

Table 2.7.1 (continued)
Rock Creek/Muddy Creek Alternatives
Summary of Potential Positive and Negative Environmental
Impacts, Mitigation Measures, and Unavoidable Adverse Impacts

		Cultural Resource	Social Environment	Economics	Transportation
POTENTIAL IMPACTS	Rock Creek	1. Disturbance of prehistoric lithic scatters. 2. High potential for disturbance of significant sites. 3. Inundation of historic stage stop.	1. Potential conflict between supporters and opponents. 2. Inundation of grazing and increase in recreation would decrease rural characteristics.	1. Recreation expenditures would have beneficial impact on 2-county region.	1. Short-term increase in vehicular traffic and traffic delays.
	Muddy Creek Site C	1. Disturbance of prehistoric lithic scatters. 2. High potential for disturbance of significant sites.	1. Loss of ranching operations. 2. Inundation of grazing and increase in recreation would decrease rural characteristics.	1. Recreation expenditures would have beneficial impact on 2-county region.	1. Short-term increase in vehicular traffic and traffic delays.
MITIGATION	Rock Creek	1. Intensive cultural resources inventory. 2. Intensive cultural resources inventory. 3. Move and/or catalogue stage stop.	1. No mitigation practical. 2. Replace AUMs by purchase of private land, or range improvement to increase carrying capacity of remainder of allotment.	1. No mitigation required.	1. Institute accepted traffic control measures.
	Muddy Creek	1. Intensive cultural resources inventory. 2. Intensive cultural resources inventory.	1. Compensate landowners. 2. Purchase private lands with purchase price compensating for forage loss.	1. No mitigation required.	1. Institute accepted traffic control measures.
UNAVOIDABLE ADVERSE IMPACTS	Rock Creek	None	Potential conflict and long-term social change.	None	None
	Muddy Creek	None	Long-term social change.	None	None

3.0. AFFECTED ENVIRONMENT

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3.0. AFFECTED ENVIRONMENT

3.1. Introduction

3.1.1. Regional Setting. This chapter describes the affected environment which is that portion of the existing environment that would be impacted by the proposed action or an alternative. The affected regional environment includes Routt County and Grand County, Colorado. Routt County includes most of the drainage basin of Rock Creek and the southern portion of the Routt National Forest. Grand County includes the Muddy Creek drainage basin and and the Middle Park portion of the Bureau of Land Management Kremmling Resource Area. The principal communities within the affected regional environment include Kremmling in Grand County and McCoy, Toponas, Yampa, Phippsburg, and Oak Creek in Routt County.

Routt County, Colorado lies just west of the Continental Divide. The county is on the border between two physiographic provinces--the Rocky Mountains and the Colorado Plateaus. Its eastern side is mostly the Park and Gore Range, an uplifted block, pre-Cambrian in age, lightly veneered by glacial till and remnant sedimentary layers. The western portion of the county contains large areas of flat-lying sediments. Tributaries of the Colorado, including Rock Creek, flow from its southern corner.

The area has long, severe winters and cool, pleasant summers typical of the Central Rocky Mountains. Average monthly temperatures vary from near 60°F in July and August to about 15°F in January. Daily temperature ranges make for comfortable daytime conditions on sunny days, even in winter. Northerly or northwesterly winds can modify this comfort factor and freezing temperatures may occur on any day of the year.

Pacific frontal systems provide most of the precipitation in the area. Most of the precipitation falls as snow during the winter months (December-April). Thunderstorms in late summer provide the next largest measure of precipitation (USDA/FS, 1979).

The Kremmling Resource Area comprises three distinct topographic regions situated in the northern reaches of the Rocky Mountains of Colorado. These regions are called North Park, Middle Park, and the Laramie River Valley. The Middle Park region encompasses most of Grand County and includes the Muddy Creek drainage basin.

Middle Park is situated on the west side of the Continental Divide and forms the headwaters for the Colorado River. The lowest point on the Colorado River in the resource area is 6,650 feet near McCoy, Colorado, where Rock Creek joins the Colorado River. Most of the public lands in Middle Park are located in the central portions of the park at elevations between 7,000 and 9,500 feet.

As with Routt County, the climate in Grand County and the Kremmling Resource Area is characterized by long, cold winters and short, cool summers with low to moderate precipitation. The prevailing winds are

westerly but are greatly affected by local topography. The growing season is short but varies widely in the area. Fluctuations of temperature and precipitation from year to year are often quite dramatic.

Season temperature ranges in the Resource Area are drastic. Summer temperature extremes may reach the upper 90's (F), while winter temperature extremes may go below -50°F. The elevation also affects the temperature. During the summer, higher elevation land may be 10 or more degrees cooler than the valleys or park floors. Winter inversions can cause the valleys to be much cooler than the surrounding higher areas. Daily fluctuations can be dramatic, especially during the early summer and early fall months. Daily temperatures may go from the 80's during the afternoon to near or below freezing (32°F) at night. The cold winter temperatures may limit recreation activities. However, the cool summer temperatures make hiking, camping, hunting, and fishing very popular activities in the area.

The Resource Area receives low to moderate amounts of precipitation. The amount is closely related to the elevation, with the precipitation increasing as the elevation increases. This rate of increase ranges from 5 to 15 inches per 1,000-foot rise in elevation for the area. Local topography can also affect the amount of precipitation due to rain shadows or channeling of storms. For example, Kremmling, where Muddy Creek joins the Colorado River, is located in a rain shadow. This rain shadow is caused by precipitation falling on the west (windward) sides and summits of nearby mountain ranges. As the storm moves across to the east side of a mountain range, little precipitation remains (USDI/BLM, 1984a).

3.1.2. Environmental Resources. The discussion of the affected environment in this chapter is organized into the following specific categories:

- Geology
- Soils
- Surface-Water Resources
- Ground-Water Resources
- Air Quality
- Vegetation
- Aquatic Biology
- Wildlife
- Land Use and Ownership
- Grazing
- Visual Resources
- Recreation Conditions
- Cultural Resources
- Paleontological Resources
- Social Conditions
- Economic Environment

All environmental resource areas considered are discussed under these specific headings.

3.2. Geology

3.2.1. Rock Creek

3.2.1.1. Regional Geology. The proposed Rock Creek dam site and reservoir area are situated on the western flank of the Gore Range, a fault block mountain range that extends generally northward from the vicinity immediately east of Vail to about the vicinity of Walton Peak some 40-45 miles north-northwest of Vail. South of the Vail area the uplift is referred to as the Tenmile Range; north of the Walton Peak area the uplift is referred to as the Park Range and extends northward into Wyoming. The core of the range is a complex of igneous and metamorphic rocks flanked on both sides by a thick sequence of sedimentary rocks, primarily sandstone and shale with a few interbedded limestones, of Cambrian to Cretaceous age (a time spanning about 480 million years from about 550 million years ago to about 70 million years ago). The igneous and metamorphic rock complex, of pre-Cambrian age (1-3 billion years ago) appears to have been uplifted along frontal faults for much of the length of the range. Some of those faults have been interpreted to be overthrusts, whereas others have been interpreted as angle reverse faults. A segment of the Gore Range west frontal fault trends generally southeastward across both Little Rock Creek Valley and Rock Creek Valley within the study area. (Western Engineers et al., 1984)

Erosion has stripped away most of the sedimentary rock cover that previously blanketed the pre-Cambrian rock complex that constitutes the core of the Gore Range, but locally fault-block inliers of Triassic-age (about 200 million years ago) and Jurassic-age (about 150 million years ago) rock have escaped complete removal. One of those inliers lies to the east of the Rock Creek-Jolley Creek confluence; another underlies an east-southeast trending valley immediately north of a narrow east-trending ridge on the north side of the Jolley Creek Valley (Fig. 2.4.1). After a well developed system of valleys had been eroded into the mountain mass, streams reinundated many of those valleys and covered the ridges with sands and clays. These constitute the Miocene-age (about 12-26 million years ago) Browns Park formation. Subsequently, much of this alluvial fill has been removed by erosion to re-expose the granitic bedrock.

The northern part of the Gore Range has been down-dropped along a fault that extends generally northeastward through Gore Pass. This fault trends across the Little Rock Creek Valley about 100 yards downstream from the proposed dam site (Western Engineers et al., 1984).

Use of the mineral resources of the Routt National Forest has been limited and sporadic in nature. Mineralization is concentrated in a few scattered areas. Activity has fluctuated with demand. Current low prices for many minerals has dampened exploration and development (USDA/FS, 1982).

Approximately 35 percent of the Routt National Forest can be classified as having a high to medium potential for locatable minerals. Locatable minerals are those valuable deposits subject to exploration and development under the U. S. General Mining Law of 1872 and its amendments.

Commonly, locatables are referred to as "hardrock" minerals. Examples include, but are not limited to, deposits of iron, gold, silver, lead, zinc, copper, and molybdenum. The Rock Creek Reservoir site has a low potential for locatable minerals.

About 30 percent of the Routt National Forest can be classified as having a high to medium potential for valuable deposits of leasable minerals. Leasable minerals include fossil fuels (coal, oil, gas, oil shale, etc.), geothermal resources, potassium, sodium, carbon dioxide, phosphates. The only leasable minerals to see development on the Forest have been oil and natural gas and none have been developed in the vicinity of the Rock Creek site.

Salable mineral materials, or common varieties, are generally low value deposits of sand, clay, and stone that are used for building materials and road surfacing. Disposal of these materials from the National Forest System is totally at the discretion of and by the Forest Service. Aggregate sources have been identified on a portion of the Forest and some aggregate sources have been identified at the Rock Creek site to support dam construction (see Section 2.4.4.1).

3.2.1.2. Site Geology. Rock Creek, in the vicinity of site B, has carved a relatively symmetrical V-shaped valley into the pre-Cambrian igneous/ metamorphic bedrock. The valley floor is about 100 feet wide where the creek meanders through flat-lying recent stream alluvium. The side slopes are about 1.5:1 and composed on the right abutment of weathered, in-place bedrock and slope wash. The base of the left abutment is skirted by talus debris originating from bedrock outcrops exposed above elevation 8580. Small alluvial fans were mapped at the mouths of steep lateral drainages both upstream and downstream of the axis. (Morrison-Knudsen Engineers, 1986)

The valley floor is composed of recent stream alluvium consisting of angular to subangular cobbles and sand derived from the adjacent igneous/ metamorphic complex. The alluvium is overlain by up to 3 feet of black, highly organic top soil.

Subsurface investigations at Site B were conducted by Morrison-Knudsen Engineers. These consisted of seismic refraction lines along the axis and perpendicular to the axis in the valley floor, supported by three rotary boreholes drilled along the centerline, one on each abutment and one in the valley floor. In addition a seismic refraction survey was made of the left abutment and spillway alignment at Site A. The investigation showed the valley floor to be covered by about 20 feet of alluvial gravel and sand. The seismic refraction work coincided with the boreholes and showed the top of sound rock to be as deep as 35 to 40 feet over the entire abutment.

The seismic refraction lines at Site A upstream showed the top of rock in the alluvial valley floor to be about 20 feet deep. The top of sound rock on the left abutment, however, ranged to a depth of 50 feet. The seismic section on the spillway alignment showed the depth to the top of sound rock to be in the 25- to 30-foot range (Morrison-Knudsen Engineers, 1986).

3.2.2. Muddy Creek

3.2.2.1. Regional Geology. Muddy Creek is in the Middle Park Basin on the western limb of the Park Range uplift. The major geologic structures which now comprise the Rocky Mountains were formed during the Laramide Orogeny of Upper Cretaceous to Eocene age, about 40 to 70 million years ago. During that age, the pre-Cambrian basement rocks were thrust over younger Jurassic and Cretaceous shale, mudstone, and sandstone along the Williams Range Thrust Fault. This is displayed on Wolford Mountain, 1 mile east of Site C, where older dark pre-Cambrian granite can be seen above the younger, light tan shale. Tertiary age volcanic rocks are also present. Surface traces of the Antelope Pass Fault zone have been found approximately 2.5 miles northeast and 2.5 miles southeast of Site C. This fault displaces the Miocene Troublesome Formation indicating post-Laramide movement on the fault (Western Engineers, 1983; Boyle, 1986).

The Bureau of Land Management Resource Management Plan/Environmental Impact Statement (USDI/BLM, 1984a) provides a summary of the mineral resources of the Kremmling Resource Area. There are no significant locatable or leasable mineral sources identified in the Resource Management Plan in the Muddy Creek Reservoir area. Sand and gravel is used for construction and road maintenance in the Middle Park area. Most of this production comes from glacial deposits scattered throughout the Kremmling Resource Area. Some aggregate sources have been identified at the Muddy Creek site to support dam construction (see Section 2.5.4.1).

3.2.2.2. Site Geology. Surficial geologic mapping at Muddy Creek Site C (Fig. 2.5.1) by Morrison-Knudsen Engineers revealed that the present Muddy Creek has incised a fairly narrow canyon about 300 feet wide into the Pierre Shale bedrock. The canyon is characterized by near vertical cliffs on either side of the creek about 75 feet high. The creek flood plain is covered with alluvial deposits of clay, sand, and gravel. The base of the cliffs are often masked by deposits of talus and slide debris associated with sloughing of the cliffs above. The bedrock is a hard, gray mudstone or shale. Surface outcrops are weathered to a friable, flakey, slivery material with separations along bedding planes. (Morrison-Knudsen Engineers, 1986)

The right abutment slopes very gently up toward Highway 40 (Fig. 2.5). The left abutment bedrock is overlain to the east a distance of 200 to 1000 feet from the canyon by landslide debris originating from high above on Wolford Mountain. The slides appear to be associated with slabbing and toppling of the outcrops of crystalline rock above the Williams Fork Thrust Fault.

Subsurface investigation by Morrison-Knudsen Engineers consisted of seismic refraction lines along the proposed centerline of the dam, across the valley downstream of the dam and on the left abutment along a possible spillway alignment. In addition, three rotary boreholes were drilled along the centerline, one on each abutment and one in the floor of the valley.

The investigation showed the alluvium in the valley floor to be from 9 to 12 feet thick consisting of about 6 feet of light brown, clayey sand overlying an additional 4 feet of gray, medium grained sand, and about 2 feet of gravel composed of well rounded granite and basalt cobbles. The upper 8 to 10 feet of bedrock (to a total depth below the surface of about 24 feet) is slightly to moderately weathered. Below that depth the bedrock is massive dark gray, sound mudstone or shale.

The seismic section along the proposed spillway alignment (Fig. 2.5) when correlated with the left abutment borehole indicates an approximately 25-foot thickness of terrace gravel overlying about 15 to 35 feet of slightly weathered but jointed mudstone or shale, to sound rock (Morrison-Knudsen Engineers, 1986).

3.2.3. Seismicity

3.2.3.1. General. An investigation of the seismotectonic hazard of the Rock Creek and Muddy Creek reservoir sites was completed in 1986 (Michael W. West and Associates, Inc., 1986). The material in this section is extracted from their report.

The project area is located in north-central Colorado in the Southern Rocky Mountain physiographic/tectonic province. The Southern Rocky Mountains are bounded on the west by the Colorado Plateau, on the northwest and west by the Wyoming Basin and on the east by the Colorado Piedmont and Great Plains. A sliver of the basin and range physiographic/tectonic province represented by the Rio Grande rift extends into south-central Colorado and perhaps further to the north.

The project is located in the northern Rio Grande rift system, about 50 miles north of the main axial graven. Dominant structural/physiographic features of the project area include the Gore/Park Range uplift, Middle Park Basin, and the northern extension of the Williams/Front Range uplift.

The historic seismicity of Colorado has been described by a number of investigators. No doubt exists that Colorado is an area of relatively low historic seismicity. The largest events felt or instrumentally recorded over the 110± year earthquake history of the state include Modified Mercalli Intensity VII and Richter magnitude Ml = 5.3 events, respectively. Moreover, no earthquakes have been unequivocally associated with known geologic structures; and no surface fault rupture has been detected anywhere in the state as the result of historic earthquake activity. The apparent discrepancy between contemporary seismicity and known tectonic structures, including the Rio Grande rift, is not unusual. Long recurrence intervals on the order of several hundred to several thousand years may explain the apparent low level of contemporary seismicity and poor spatial relationship to known Quaternary faults in Colorado.

Earthquake activity in the Rock Creek/Muddy Creek project area and, indeed, most of Colorado has been infrequent and of relatively low level. Consequently, few seismograph stations have been established in the region. Current instrumental detection and location capability for events of

magnitude 3.0 to 3.5 or greater is on the order of several tens of kilometers. Prior to 1960, events were located from felt reports.

Apparently no ground shaking due to earthquakes has been recorded or felt in the vicinity of the project site during historic time. The nearest earthquakes, about 25 miles (40 km) distant, were less than or equal to Richter magnitude Ml=3.0. Insufficient recorded earthquake activity exists in the project area to determine seismogenic potential of specific faults. Therefore, determination of seismogenic potential rests entirely on geologic evidence.

Assessment of seismotectonic hazards for the Rock Creek/Muddy Creek area requires consideration of potential earthquake source zones, either identifiable faults or larger areas with common seismic characteristics. Once potential source zones have been identified, design earthquakes are assigned based on a synthesis of geological and seismological data. The Maximum Credible Earthquake (MCE), defined as the largest event likely to occur on a seismogenic structure in the contemporary geologic/tectonic setting, is normally used in the design of high hazard dams.

Potential seismotectonic hazards to the proposed Rock Creek and Muddy Creek dam and reservoir sites include strong ground shaking associated with hypothetical maximum credible earthquakes, surface fault rupture in the proposed dam foundations, liquefaction potential, earthquake-induced landsliding at the dam sites and around the reservoir rims, reservoir seiche and reservoir-induced seismicity.

3.2.3.2. <u>Surface Faulting</u>. Both Rock Creek sites are located in a structurally complex area near the intersection of the Gore and Gore Pass fault zones. A strong likelihood exists that faulting or shearing related to these two fault systems are present in both dam foundations. No faults, however, have been proven to exist in either foundation area. Drilling performed by Morrison-Knudsen Engineers (1986) at Site A disclosed no conclusive evidence of faulting in the proposed dam foundation.

The potential for fault surface rupture is wholly dependent on a determination of seismogenicity for the faults in question. No substantive evidence indicates the Gore, Gore Pass, or related faults are seismogenic based on current knowledge. Accordingly, it is believed that the potential for surface rupture in either dam foundation is low and need not be taken into consideration at this level of design. The origin of lineaments in the Long Park area, one mile west of the sites, however, could alter this opinion should they prove to be related to seismogenic surface faulting, a possibility that is yet to be proven.

Muddy Creek Site A (see Section 2.2.2.4) is located near the southern end of the Antelope Pass fault zone. In this area, faulting is manifested by a series of northwest- and northeast-striking block faults. None of these faults, however, have been shown to pass through the dam foundation. Moreover, the Antelope Pass fault has not moved since at least mid--Pleistocene time based on geologic evidence north of Wolford Mountain and lack of geomorphic surface expression near Site A. Accordingly, the potential for fault surface rupture at Site A is considered to be low.

No faults have been mapped or detected by drilling in the proposed dam foundation at Site C, in the reservoir basin, or in the immediate vicinity. It can be concluded, therefore, that hazards due to surface fault rupture at Site C are low to virtually nonexistent.

3.2.3.3. Liquefaction. Liquefaction potential at both the Rock Creek and Muddy Creek sites is dependent on the presence of low-density, saturated, cohesionless materials in the dam foundations and/or embankments and on the characteristics of expected earthquake loadings. Data obtained from drilling performed by Morrison-Knudsen Engineers, Inc., indicates no potentially liquifiable materials are present at the sites. Removal of unconsolidated materials from the foundation areas at the proposed dam sites should reduce or eliminate liquefaction potential. Bedrock at all sites is not subject to liquefaction.

3.2.3.4. Earthquake-Induced Landslides. Natural slopes in the vicinity of Rock Creek Sites A and B and Muddy Creek Site A and around the respective reservoir rims appear to be relatively stable in their natural, undisturbed states. Ground shaking associated with earthquakes of magnitude Ml = 5.5 in the vicinity of each site could conceivably cause minor sloughing and slumping of colluvial soils overlying bedrock around reservoir rims. Minor slope failures, however, should not affect the structural integrity nor cause overtopping of the proposed dams. The likelihood of a magnitude Ml = 5.5 earthquake occurring in the immediate vicinity of a dam during the life of the project is considered low.

3.2.3.5. Reservoir Seiche. The absence of credible surface faulting within the alternative reservoir basins suggests that overtopping of dams resulting from surface fault displacement is low. Similarly, tectonic tilt, subsidence, and ground lurching are not considered credible hazards based on available information. The probability of reservoir seiche caused by these mechanisms, therefore, is believed to be low to non-existent. Earthquake ground motions should not produce reservoir seiche of sufficient amplitude to cause overtopping.

3.2.3.6. Reservoir-Induced Seismicity. Previous studies of documented cases of reservoir-induced seismicity suggest reservoirs of at least 1,000,000 acre- feet total volume with water depths of 300 feet or greater located in actively extending geological terrain are most likely to be associated with induced events. The small size of the proposed reservoirs both in terms of depth (maximum depth = 175 feet) and volume (maximum volume = 50,000 acre- feet) suggest reservoir-induced seismicity should not be a significant hazard.

3.2.3.7. Conclusions. Based on the results of the geological and seismological studies by Michael W. West and Associates, Inc. (1986), it was concluded:

1. The Antelope Pass fault is non-seismogenic and need not be considered in project design. Segments of the Gore Fault, Gore Pass fault, Monument Creek fault, and other faults in the project area show no conclusive evidence of seismogenic movement. Lineaments and geomorphic features apparently associated with the Gore Fault one mile west of the Rock Creek sites are suggestive of seismogenic movement but may be explained by non-tectonic mechanisms as well. Data are insufficient to characterize these lineaments as seismogenic.

2. Hypothetical "floating" events of Richter magnitudes Ml = 5.5 occurring at hypocentral distances of 10.0 from each dam represent a conservative assessment of potential earthquake hazards for the project. Peak bedrock horizontal accelerations ranging from 0.20g to 0.34g may be associated with hypothetical "floating" events.

3. Other seismically-induced hazards including surface faulting, liquefaction, reservoir seiche, and induced seismicity are believed low to virtually non-existent in the project area.

3.3. Soils

3.3.1. Rock Creek. The following soils descriptions were developed utilizing information obtained from the Forest Service (USDA/FS, 1986b), extrapolation of soil descriptions presented in the Grand County Soil Survey (USDA/SCS, 1983) since a detailed soil survey has not been completed for the Rock Creek Study Area, and onsite soil investigations and correlations with the previously mentioned sources of information.

The vast majority of soils in the study area have formed from granitic rock. Other minor parent materials include metamorphic rock (gneiss), siltstones, shales, mudstones, conglomerates, sandstones, and alluvial, colluvial and glacial deposits (Tweto, 1976). The soils are generally acidic with pH ranging from 6.0 to 4.2. All the soils have developed under a very cold (cryic) temperature regime. Most of the soils in the study area are relatively young and show only the earliest stages of development (Entisols and Inceptisols); some of the soils have formed in environments more conducive to development (Alfisols and Mollisols).

Soils in the area are generally distributed according to topographic position and predominant vegetation type. Integrating these two factors of soil formation produces roughly four general soil units. These include steep upper slopes covered with mountain big sagebrush, gentle lower slopes covered with both mountain big sagebrush and silver sagebrush, ridgelines and slopes covered with coniferous forest, and wet valley bottoms. Table 3.3.1 lists the approximate area of each unit in the 19,265-acre study area. An interpretation of the limitations and suitability of each soil unit is presented in Table 3.3.2. based on the existing information and criteria listed in any modern soil survey such as for Grand County, CO (USDA/SCS, 1983).

Table 3.3.1
Soil Units and Acreages that Occur in the Rock Creek Study Area

Soil unit	Area (ac)	Percent of total area
Steep upper slopes covered with mountain big sagebrush	2,690	14
Gentle lower slopes covered with mountain big sagebrush and silver sagebrush	1,283	7
Ridgelines and slopes covered with coniferous forest	13,464	70
Wet valley bottoms	1,739	9
TOTAL	19,265	100

The soils on the steep upper slopes covered with mountain big sagebrush are shallow to moderately deep, well drained, and have rapid permeabilities. Predominant soil texture ranges from a gravelly sandy loam to a very gravelly sandy loam. Rock outcroppings or shallow depths to bedrock are included in this soil type and result in a relatively high coarse fragment content (20 to 60 percent). Depth to groundwater is deep. Vegetal cover ranges from 20 to 60 percent. Slope gradients range from near level to 60 percent, with an average slope of approximately 30 percent. Runoff potential is medium and erosion hazard is slight to moderate. These soils are poorly developed and have moderate to severe limitations to building site development and sanitary facilities, slight to severe limitations to recreation development, and are an unsuited to good source of construction materials. Most of the limitations are due to steep slope, shallow depth to bedrock, and large stones.

Soils on the gentle lower slopes covered by mountain big sagebrush and silver sagebrush are deep, well drained, and have moderately slow to moderately rapid permeabilities. Depth to groundwater is deep, but a temporarily high water table may occur during and shortly after the snowmelt season. Soil texture is primarily a sandy loam, but may range from gravelly sandy loam to clay. Typically, an illuvial clay horizon is present between 16 and 20 inches from the soil surface. Vegetal cover ranges from 40 to 90 percent. Slope gradients are mild and average approximately 15 percent. Runoff potential is slow to medium and erosion hazard is slight. These

Table 3.3.2. Limitations and suitability of soils in the Rock Creek study area for various types of development. Reasons for unsuited to fair ratings are also listed [interpretations based on criteria presented in SCS (1982).]

Type of Development	SOIL UNIT: Steep upper slopes covered with mountain big sagebrush	Gentle lower slopes covered with mountain big sagebrush and silver sagebrush	Ridgelines and slopes covered with coniferous forests	Wet valley bottoms
<u>Building Site Development</u>				
-shallow excavations -dwellings w/out basements -dwellings w/basements -small commercial buildings -local roads and streets	Moderate to Severe: -slope -depth to rock -large stones	Slight to Moderate: -cut banks cave -large stones	Slight to Severe: -depth to bedrock -large stones -slope	Severe: -high water table -flooding
<u>Sanitary Facilities</u>				
-Septic tank absorption fields	Moderate to Severe: -slope -depth to bedrock -large stones	Slight to Moderate: -depth to seasonal -high water table	Slight to Severe: -depth to bedrock -large stones -slope	Severe: -high water table -flooding -slow permeability
<u>Construction Materials</u>				
-roadfill -sand -gravel -topsoil	Unsuited to Good: -slope -depth to bedrock -large stones -shallow	Fair to Good: -large stones	Unsuited to Good: -slope -depth to bedrock -large stones -shallow	Unsuited to fair: -wetness -fine texture
<u>Recreation Development</u>				
-camp areas -picnic areas -playgrounds	Slight to Severe: -slope -depth to bedrock -large stones -shallow -dust	Slight to Moderate: -dust	Slight to Severe: -slope -depth to bedrock -large stones -shallow -dust	Severe: -high water table -flooding

soils are generally well developed and have slight to moderate limitations to building site development, sanitary facilities, and recreation development, and are a fair to good source of construction materials. The major limitations include caving of cutbanks, large stones, and shallow depth to the seasonally high water table.

Soils on ridgelines and slopes covered with coniferous forests are shallow to deep, well drained, and have moderate to moderately rapid permeabilities. Depth to groundwater is generally deep, but on lower slopes a temporarily high water table may occur during and shortly after the snowmelt season. Soil texture is primarily a sandy loam, but may range from a sandy clay loam to a very gravelly sandy loam. Coarse fragment content is generally low, but near rock outcroppings or in areas with shallow depths to bed rock may be as high as 70 percent. Vegetal cover ranges from 50 to 100 percent. Slope gradients average approximately 15 percent and range from near level to 60 percent. Runoff potential is medium to rapid, and erosion hazard is slight to moderate. These soils have slight to severe limitations to building site development, sanitary facilities, and recreation site development, and are an unsuited to good source of construction materials. Most of the limitations are due to slope, shallow depth to bedrock, and large stones.

Soils on wet valley bottoms are typically covered by a mosaic of grasses and forbs, and willow and associated shrubs. These soils typically occur in a perennially wet or saturated environment due to a very shallow water table. Soil depth is deep. Vegetal cover is typically near 100 percent. Slope gradients are generally less than 10 percent. These soils are very poorly drained and have slow to moderately slow permeabilities. Soil texture is typically a loamy sand but may range from a clay loam to a very gravelly sandy loam. Runoff is very slow to slow and erosion hazard is very low except along stream cutbanks. These soils are generally poorly developed and have a severe limitation to building site development, sanitary facilities and recreation site development, and are an unsuited to fair source of construction materials. Major limitations include perennial wetness, high water table, slow permeability, and flooding.

3.3.1.1. Important Farmlands. Prime farmlands include soils that provide the best combination of physical and chemical conditions for growing food, feed, forage, fiber, or oil seed crops. These soils include only those areas that are currently under production or are available for conversion to farmland. There are no prime farmlands in the study area because the cold climate of the study area and the lack of agriculturally productive soils do not meet the criteria established for identification of prime farmland (USDA/SCS, 1982 and 1983).

State important farmlands include areas that are not prime farmlands but are important to the county or state economy. No prime, unique, state or locally important farmlands occur in the Rock Creek Study area (McCullough, 1986).

3.3.2. Muddy Creek. Soils in the study area have been mapped in detail as part of the Soil Survey of Grand County, Colorado (USDA/SCS, 1983). Soils have formed primarily from sedimentary rock including shales and sandstones of the Pierre Shale, Niobrara, and Benton Shale formations, as well as from more recent alluvial and colluvial deposits such as loose material on slopes and sediment deposited along streams (Tweto, 1976). The majority of the soils formed under a very cold (cryic) temperature regime. Under these conditions, soil formation and chemical reactions are slow, resulting in relatively low soil fertility (USDI/BLM, 1984a). Due to the predominantly sedimentary parent material, soil reaction is generally basic, with a pH ranging from 6.0 to 9.0.

A wide array of diverse geologic, topographic, hydrologic, and biologic conditions occurs across the study area, creating a large variety of soil types or mapping units. The study area includes many of the 95 soil mapping units described in the Soil Survey of Grand County, CO (USDA/SCS, 1983). The following soils descriptions are a summary of the information included in the Grand County Soil Survey as well as on-site soils observations. The soils can be described in very general soil associations. These associations are grouped primarily by topographic position, land form, and elevation. The predominant associations in the study area are the Cumulic Cryaquolls-Tine, Aaberg-Waybe-Binco, Harsha-Levitt, Cimarron-Mayworth-Mord and Quander-Youga-Anvik. Table 3.3.3 lists the approximate area of each soil association in the 21,600 acre study area. These associations are described below and their suitability and limitations to various types of development are listed in Table 3.3.4.

3.3.2.1. The Cumulic Cryaquolls-Tine Association. This association occurs within the entrenched Muddy Creek valley and associated major drainages. These are deep, nearly level to steep, poorly drained to well drained soils that formed in outwash and alluvium on terraces, fans, and floodplains. These soils are primarily loams and range from heavy clay loam to very cobbly sandy loam.

Table 3.3.3.
Soil Associations and Acreages that Occur in the Muddy Creek Study Area

Soil association	Area (ac)	Percent of total area
Cumulic Cryaquolls-Tine	7,360	34
Aaberg-Waybe-Binco	1,840	9
Harsha-Leavitt	12,260	57
Cimarron-Mayoworth-Mord	80	< 1
Quander-Youga-Anvink	60	< 1
TOTAL	21,600	100

Table 3.3.4. Limitations and suitability of soils in the Muddy Creek study area for various types of development. Reasons for unsuited to fair ratings are also listed [summarized from SCS (1982)].

Type of Development	Mapping Units						
	Cumulic-Cryaquoll	Tine	Aaberg	Waybe	Binco	Harsha	Leavitt
Building Site Development							
Including: -shallow exacavations -dwellings w/out basements -dwellings with basements	Severe Limitations: -cut banks cave -shallow water table -percolation slow	Severe Limitations: -slope -cut banks cave -large stones	Moderate to Severe Limitations: -too clayey -slope -shrink-swell -low strength	Severe Limitations: -slope -depth to bed rock -low strength	Moderate to Severe Limitations: -slope -too clayey -shrink-swell -low strength	Slight to Severe Limitations: -slope -low strength -shrink-swell	Slight to Severe Limitations: -slope -shrink-swell -low strength
Sanitary Facilities							
Including: -septic tank absorption fields	Severe Limitations: -shallow water table -percolation slow -susceptibility to flooding	Severe Limitations: -large stones	Severe Limitations: -percolation slow -depth to bedrock -slope	Severe Limitations: -slope -depth to bedrock -percolation slow	Severe Limitations: -percolation slow -slope	Moderate to Severe Limitations: -slope -percolation slow	Moderate to Severe Limitations: -percolation slow -slope
Construction Materials							
Including: -roadfill -sand -gravel -topsoil	Unsuited to Fair Limitations: -perennial wetness	Poor to Fair Limitations: -large stones -slope -small stones	Unsuited to Poor Limitations: -too clayey -shrink-swell -low strength -thin layer -slope	Unsuited to Poor Limitations: -slope -thin layer -low strength -too clayey	Unsuited to Poor Limitations: -low strength -shrink swell -slope -too clayey	Unsuited to Fair Limitations: -low strength -slope -too clayey	Unsuited to Fair Limitations: -shrink-swell -low strength -frost action -too clayey
Recreation Site Development							
Including: -camp areas -picnic areas -playgrounds -paths and trails	Unsuited to Poor Limitations: -perennial wetness -percolation slow	Moderate to Severe Limitations: -stones -slope	Moderate to Severe Limitations: -too clayey -slope	Severe Limitations: -slope -depth to bed rock	Moderate to Severe Limitations: -too clayey -slope	Slight to Severe Limitations: -slope	Slight to Severe Limitations: -slope

Table 3.3.4. Continued

Type of Development	Mapping Units					
	Cimarron	Mayworth	Mord	Quander	Youga	Anvink
Building Site Development						
Including: -shallow excavations -dwellings w/out basements -dwellings w/basements -small commercial buildings	Moderate to Severe Limitations: -slope -too clayey -shrink-swell -low strength	Moderate to Severe Limitations: -slope -shrink-swell -low strength -too clayey	Moderate to Severe Limitations: -slope -too clayey -shrink-swell -low strength	Severe Limitations: -slope -large stones	Slight to Severe Limitations: -slope -shrink-swell -low strength	Moderate to Severe Limitations: -slope -low strength -shrink-swell
Sanitary Facilities						
Including: -septic tank absorption fields	Severe Limitations: -percolation slow -slope	Severe Limitations: -slope -depth to rock -percolation slow	Severe Limitations: -percolation slow -slope	Moderate to Severe Limitations: -slope -percolation slow -large stones	Severe Limitations: -slope -percolation slow	Severe Limitations: -slope
Construction Materials						
Including: -roadfill -sand -gravel -topsoil	Unsuited to Poor Limitations: -shrink-swell -slope -low strength -too clayey	Unsuited to Poor Limitations: -slope -thin layer -shrink-swell -too clayey	Unsuited to Fair Limitations: -shrink-swell -low strength -small stones -slope	Unsuited to Fair Limitations: -large stones -slope	Unsuited to Poor Limitations: -slope -low strength -small stones	Unsuited to Fair Limitations: -low strength -large stones -slope -thin layer
Recreation Development						
Including: -camp areas -picnic areas -playgrounds -paths and trails	Slight to Severe Limitations: -percolation slow -slope	Moderate to Severe Limitations: -slope -too clayey	Slight to Severe Limitations: -percolation slow -slope	Severe Limitations: -large stones -slope	Slight to Severe Limitations: -percolation slow	Slight to Severe Limitations: -slope

A large proportion of this association is comprised of the Cumulic Cryaquolls mapping unit. This soil occurs on the floodplain of Muddy Creek where a high water table or subirrigated condition exists. These soils are poorly drained, have a very slow to slow permeability, slow runoff, and a slight erosion hazard. Effective rooting depth is generally shallow and available moisture is high. Much of this soil remains flooded or saturated during much of the growing season. Seasonal flooding and depth to the water table are considered to be the most limiting developmental features. A large portion of this mapping unit supports hay production in addition to pasture grazing and wildlife habitat.

The Tine series occurs on the gentle slopes adjacent to the Cumulic Cryaquolls on deep, well drained terraces and fans. Permeability is rapid, surface runoff is slow, erosion hazard is slight to moderate, available water capacity is low, and effective rooting depth is 60 inches or greater. This soil has severe limitations to building site development, sanitary facilities, and recreation development, and is a poor to fair source of building materials. This soil supports range grazing and is covered by sagebrush, rabbitbrush, and greasewood.

3.3.2.2. Aaberg-Waybe-Binco Association. The soils of this association are shallow to deep, gently sloping to very steep, well drained soils that formed in alluvium and residuum derived from shale, claystone and mudstone. They are located on fans, side slopes and ridges adjacent to the Muddy Creek flood-plain. Soil texture ranges from clay loams at the surface to heavy clay loams, clays, or clays over shale at greater depths. These soils have slow permeabilities. Rooting depth ranges from 10 to over 60 inches. Available water capacity, surface runoff, and erosion hazard depend primarily on slope gradient and soil depth. Deeper soils on gentler slopes have medium surface runoff, high available water capacity, and slight to moderate erosion hazard. Shallower soils on steeper slopes have low available water capacities, rapid surface runoff, and moderate to high erosion hazard. These soils have moderate to severe, but mostly severe limitations to building site development, sanitary facilities, and recreation development, and are an unsuited to poor source of building materials. These soils are covered by sagebrush, which is used for rangeland grazing and wildlife habitat. Some areas on the relatively flat terraces have been cleared of natural vegetation for irrigated hay production.

3.3.2.3. Harsha-Leavitt Association. Soils of this association are deep, nearly level to steep, and well drained. They formed from alluvium and occur on sideslopes, fans and terraces. These soils are located on the relatively flat terraces and gentle to steep slopes adjacent to and above the encised Muddy Creek valley. Texture ranges from loam at the soil surface to a clay loam subsoil. These soils have a moderate permeability, a high available water capacity, and a 60-inch or greater rooting depth. Surface runoff is slow to rapid and erosion hazard is slight to high depending on slope gradient. These soils have slight to severe limitations to building site development, sanitary facilities, and recreation site development, and are an unsuited to fair source of building materials. The soils are covered by sagebrush and the predominant land use is range-

land grazing and wildlife habitat. Some areas on the relatively flat terraces have been cleared of native vegetation for irrigated hay production.

3.3.2.4. Cimarron-Mayworth-Mord Association. These soils are well drained and occur on gently sloping to steep mountainsides, ridges and fans. They formed from alluvium, residuum, and glacial drift consisting primarily of shales and some mixed rock. These soils are located primarily on steep mountain slopes above the terraces surrounding the encised Muddy Creek canyon. Soil textures range from loams and clay loams at the soil surface to sandy loams, clay loams, clays, and gravelly clay loams at greater depths. Soil permeability is slow and available water capacity is low to high. Effective rooting depth ranges from 20 to over 60 inches, surface runoff slow to rapid, and erosion hazard slight to high depending on slope gradient. These soils have a slight to severe limitation to building site development, sanitary facilities, and recreation site development, and are an unsuited to fair source of building materials. These soils are used primarily for rangeland grazing, wildlife habitat, and recreation, and are covered by sagebrush and some aspen.

3.3.2.5. Quander-Yarga-Anvink Association. These soils are deep, gently sloping to steep, well drained, and formed in colluvium and glacial drift from mixed rocks on mountainsides, ridges, and fans. They occur on mountain slopes above the relatively flat terraces surrounding the encised Muddy Creek canyon. Surface soil texture ranges from loam to cobbly loam, and subsurface texture ranges from very cobbly sandy clay loam to extremely stony clay loam. Soil permeability ranges from moderately slow to moderate, available water capacity ranges from moderate to high, and effective rooting depth is 60 inches or greater. Surface runoff ranges from slow to medium, and erosion potential ranges from moderate to high depending on slope gradient. These soils have slight to severe limitations to building site development, sanitary facilities, and recreation site development, and are an unsuited to fair source of building materials. These soils are used primarily for range grazing, wildlife habitat, and recreation, and are covered by sagebrush and aspen.

3.3.2.6. Important Farmlands. There are no prime farmlands in the study area because the cold climate of the study area does not meet the criteria established for identification of prime farmland as described in Section 3.3.1 (USDA/SCS, 1982 and 1983). Artificially or naturally irrigated lands that are cropped regularly are considered state important farmlands and are of local importance. Within the study area, state important farmlands include areas on the terraces that have been cleared of natural vegetation and put into hay production or converted to pasture through the use of flood or sprinkler irrigation. Also included in this category are hay fields and pastures located on the floodplains of Muddy Creek and associated tributaries where either natural subirrigation or artificial irrigation occurs. Approximately 4,358 acres qualify as farmlands of state and local importance representing 20 percent of the study area.

3.4. Surface Water Resources

3.4.1. Hydrology

3.4.1.1. Rock Creek. The Rock Creek drainage basin is located in north-central Colorado in the upper reaches of the Colorado River. It lies in portions of Eagle, Grand, and Routt counties. Rock Creek watershed ranges in elevation from 6,600 feet near its confluence with the Colorado River to approximately 11,000 feet in the Gore and Flat Top ranges. Total watershed area is about 188 square miles (sq mi) while the contributing area above the damsite is approximately 53 sq mi. Rock Creek flows in a southwesterly direction through the proposed damsite where it subsequently is joined by Egeria and Red Dirt creeks before joining the Colorado River (see Fig. 3.4.1). A U. S. Geological Survey (USGS) gaging station, Rock Creek near Toponas (09060500) was located about 1 mile upstream of the proposed damsite, and above the confluence with Horse Creek. Horse Creek is a major ungaged tributary which has an area of approximately 4.5 sq mi. The gages on Rock Creek are as follows:

Number	Name	Years of Record
09060500	Rock Creek near Toponas	1953 - 1980
09060550	Rock Creek near Crater	1985 - Present
09060770	Rock Creek at McCoy	1982 - Present

The flow at the damsite was estimated by determining the yield per square mile at the Toponas gage, multiplying this by 4.5 to determine the estimated yield of Horse Creek, and then adding this to the gaged flow at the Toponas gage. The resulting yield for Rock Creek at the Rock Creek damsite (Site A) is shown in Table 3.4.1. Based on a scaling of contributing drainage area, the flows at Site B would be increased by about 1 percent. Fig. 3.4.2 shows the annual total inflow volumes for Site A for the period of record. Based on these data, the probability of exceedance and return period for the annual flows for the period of record are given in Table 3.4.2. Based on Table 3.4.2 and supplementary investigations of drought periods on the West Slope, a 1977 type year can be characterized as an extreme dry year or drought, with a drought frequency return period of about 1:20. A 10 cfs (or inflow) year-round instream flow requirement (established by the Colorado Water Conservation Board) must be provided in Rock Creek. In addition, between April and September, 15 cfs is required for other downstream demands on Rock Creek; therefore, there is a minimum flow requirement in Rock Creek of 25 cfs, or inflow, whichever is less, during this period.

3.4.1.2. Muddy Creek. The Muddy Creek drainage basin is located in north-central Colorado in the upper reaches of the Colorado River. It lies in portions of Grand, Jackson, and Routt counties. Muddy Creek watershed ranges in elevation from 7,340 feet near its confluence with the Colorado River to approximately 11,000 feet in the Gore and Rabbit Ears ranges. Total watershed area is about 290 sq mi. Muddy Creek represented significantly more problems than Rock Creek in developing yield estimates, as there was no long-term record at or near the damsite. Schematics of the

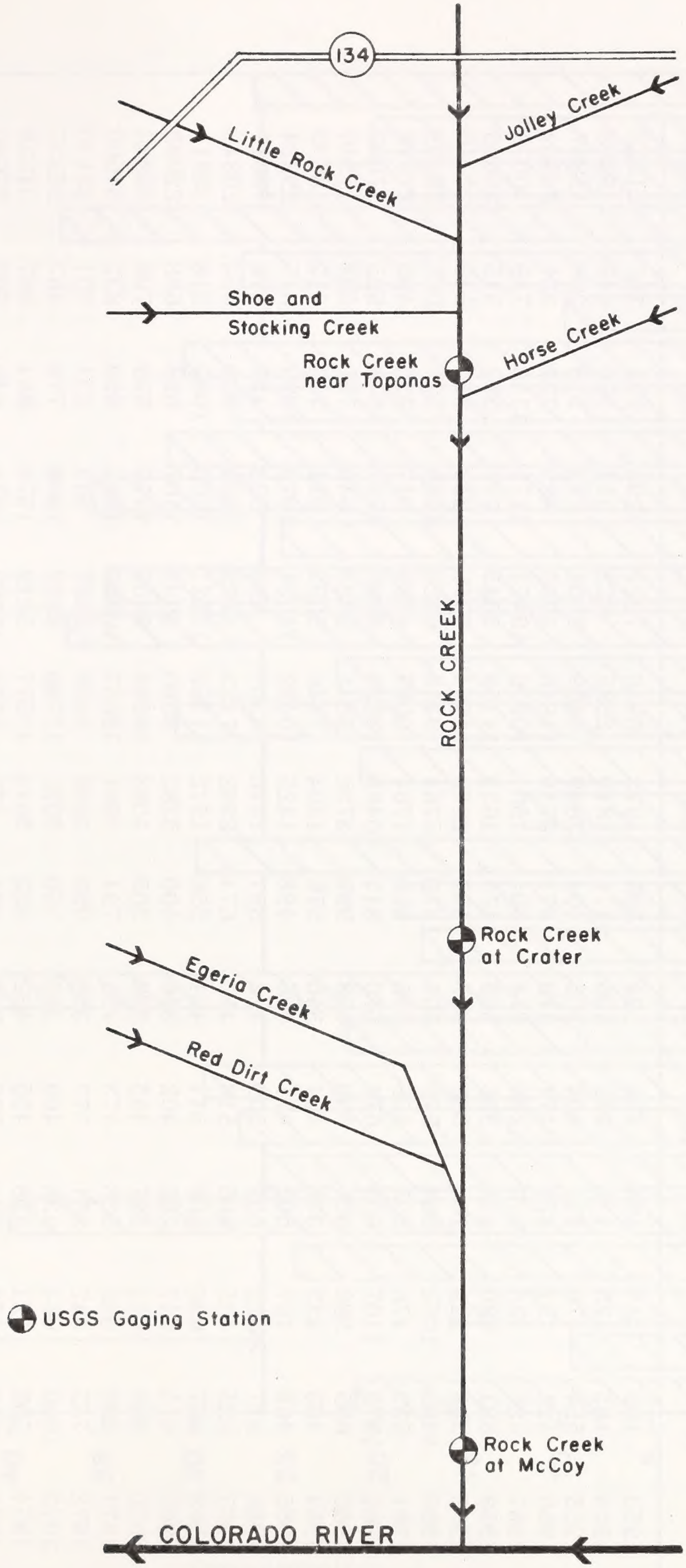


Fig. 3.4.1. Schematic diagram of Rock Creek drainage.

Table 3.4.1 Rock Creek Site Monthly Inflows - 1953-1982

Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual Total
	Monthly Flows (Acre Feet)												
1953	469	445	404	438	334	505	1973	6948	7222	1293	737	355	21123
1954	465	525	471	471	426	471	1819	2685	822	414	350	449	9368
1955	554	476	471	404	305	404	2849	6159	2805	643	518	298	15887
1956	424	457	471	471	410	471	3715	11846	4230	889	724	331	24439
1957	426	425	370	236	274	404	1501	10936	19473	4175	1140	718	40079
1958	881	580	438	336	365	471	1633	14158	5545	777	393	515	26093
1959	588	529	404	336	365	505	2279	11704	7956	1249	887	643	27446
1960	1490	1072	634	573	504	1370	5764	9446	6126	1249	575	605	29409
1961	533	476	505	438	396	515	1764	9095	4789	947	630	1490	21578
1962	1973	1107	809	674	670	811	10465	18629	8986	1797	648	525	47092
1963	695	588	606	539	608	999	3726	5545	2323	645	727	538	17540
1964	453	455	336	404	346	576	1304	7846	5052	911	734	412	18830
1965	468	467	505	471	426	498	1425	10432	11024	1973	1089	1047	29824
1966	917	522	539	505	426	557	1710	4307	999	523	435	578	12017
1967	625	435	466	518	473	674	2992	7123	4778	1304	800	654	20842
1968	667	630	568	541	491	556	1512	11462	11221	1666	1080	518	30913
1969	611	547	465	402	346	400	5282	8580	2992	1107	688	668	22089
1970	895	641	557	445	339	305	4098	18268	8405	1479	699	706	36836
1971	832	595	536	473	436	794	3901	12657	10860	1885	859	832	34660
1972	753	442	351	373	358	956	3605	9468	6597	944	534	751	25130
1973	1000	664	438	409	339	350	5052	15780	8252	1808	779	467	35337
1974	502	521	428	455	432	622	5644	13577	5819	1578	864	887	31328
1975	618	558	390	233	230	281	575	9523	12262	1874	640	502	27686
1976	477	416	402	546	512	421	8843	11780	5107	984	503	445	30436
1977	427	340	526	366	307	442	1589	3068	776	668	666	480	9655
1978	684	846	691	498	478	661	1929	8230	10706	1633	514	363	27231
1979	470	500	512	512	462	512	7682	14038	9643	1688	721	353	37092
1980	318	311	315	375	339	415	1896	13391	6444	1151	488	453	25893
1981	603	422	442	502	461	642	2891	6864	4597	1265	763	622	20073
1982	902	584	451	345	371	478	1671	14382	5626	796	398	530	26535
AVERAGE	691	552	483	443	408	569	3370	10264	6714	1310	686	591	26082
MAXIMUM	1973	1107	809	674	670	1370	10465	18629	19473	4175	1140	1490	47092
MINIMUM	318	311	315	233	230	281	575	2685	776	414	350	298	9368

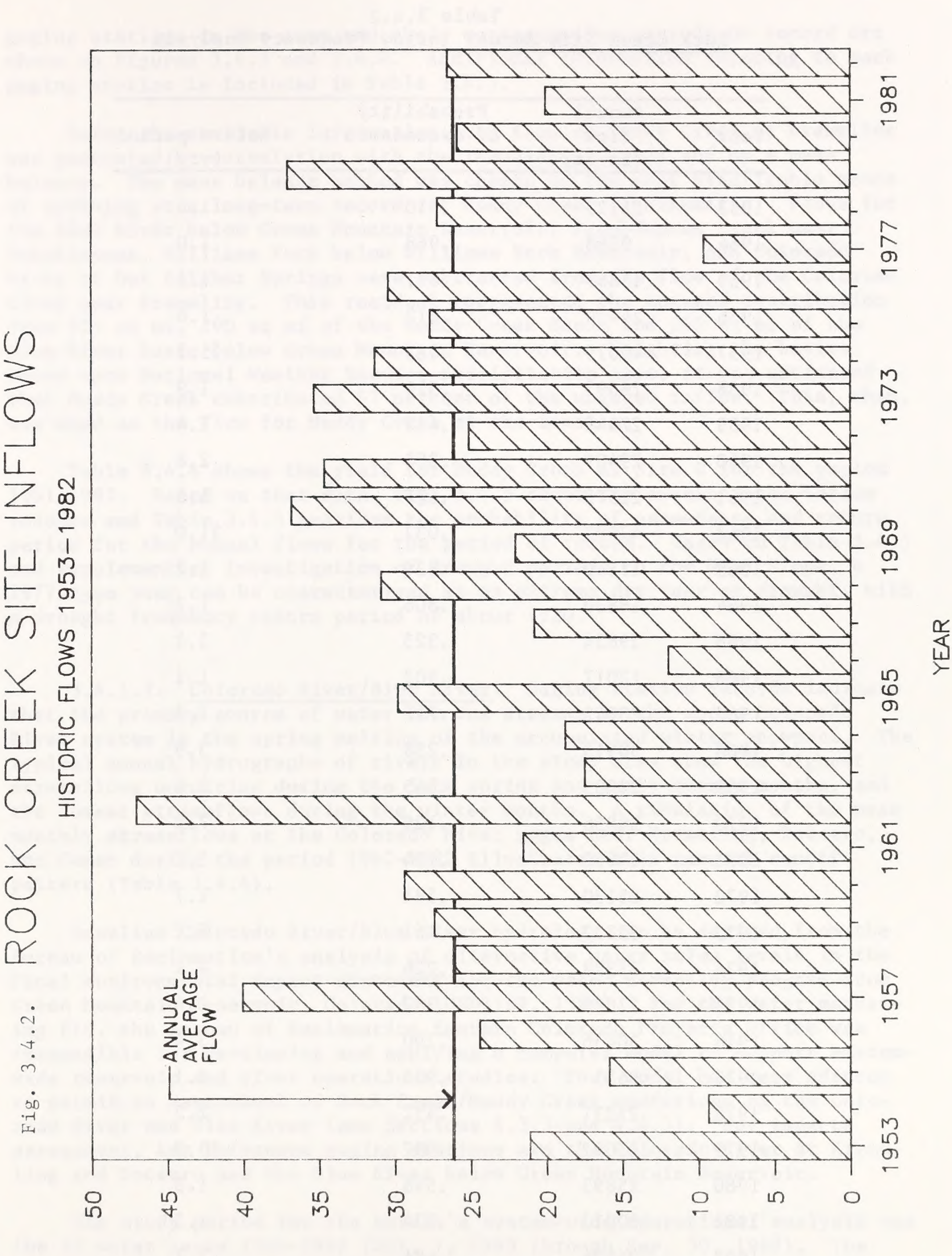

ROCK CREEK SITE INFLOWS
HISTORIC FLOWS 1953-1982
ANNUAL AVERAGE FLOW
ACRE FEET (thousands)
50
45
40
35
30
25
20
15
10
5
0
1953
1957
1961
1965
1969
1973
1977
1981
YEAR

Fig. 3.4.2.

Table 3.4.2
Rock Creek Site Annual Inflow Frequency Analysis

Year	Annual flow (ac-ft)	Probability of exceedance	Return period (yrs)
1953	21123	.710	1.4
1954	9368	.968	1.0
1955	15887	.871	1.1
1956	24439	.613	1.6
1957	40079	.065	15.5
1958	26093	.516	1.9
1959	27446	.419	2.4
1960	29409	.355	2.8
1961	21578	.677	1.5
1962	47092	.032	31.0
1963	17540	.839	1.2
1964	18830	.806	1.2
1965	29824	.323	3.1
1966	12017	.903	1.1
1967	20842	.742	1.3
1968	30913	.258	3.9
1969	22089	.645	1.6
1970	36836	.129	7.8
1971	34660	.194	5.2
1972	25130	.581	1.7
1973	35337	.161	6.2
1974	31328	.226	4.4
1975	27686	.387	2.6
1976	30436	.290	3.4
1977	9655	.935	1.1
1978	27231	.452	2.2
1979	37092	.097	10.3
1980	25893	.548	1.8
1981	20073	.774	1.3
1982	26535	.484	2.1

Mean flow for period of record -- 26082 ac-ft

gaging stations in the area and their corresponding periods of record are shown on Figures 3.4.3 and 3.4.4. Additional information relating to each gaging station is included in Table 3.4.3.

Using the available information, the flow of Muddy Creek at Kremmling was generated by correlation with the Troublesome Creek and by a mass balance. The mass balance method was chosen as the most practicable means of arriving at a long-term record for Muddy Creek at Kremmling. Flows for the Blue River below Green Mountain Reservoir, Troublesome Creek near Troublesome, Williams Fork below Williams Fork Reservoir, and Colorado River at Hot Sulphur Springs were subtracted from the flow of the Colorado River near Kremmling. This residual represented the ungaged contribution from 555 sq mi, 290 sq mi of the Muddy Creek Basin and 265 sq mi of the Blue River Basin below Green Mountain Reservoir. Weighting the basins based upon National Weather Service precipitation maps, it was estimated that Muddy Creek contributed 57 percent of the ungaged inflow. This, then, was used as the flow for Muddy Creek at the damsite.

Table 3.4.4 shows the yield for Muddy Creek at Site C for the period 1961-1982. Based on that data, Fig. 3.4.5 shows the annual total inflow volumes and Table 3.4.5 provides the probability of exceedance and return period for the annual flows for the period of record. Based on Table 3.4.5 and supplementary investigation of drought periods on the West Slope, a 1977 type year can be characterized as an extreme dry year or drought, with a drought frequency return period of about 1:20.

3.4.1.3. Colorado River/Blue River. Gaging station records indicate that the primary source of water for the streams in the upper Colorado River system is the spring melting of the accumulated winter snowpack. The typical annual hydrographs of rivers in the study area show the highest streamflows occurring during the late spring and early summer months, and the lowest streamflows during the winter months. A tabulation of the mean monthly streamflows at the Colorado River gages near Kremmling, Dotsero, and Cameo during the period 1962-1982 illustrates this general runoff pattern (Table 3.4.6).

Baseline Colorado River/Blue River hydrology can be derived from the Bureau of Reclamation's analysis of alternative water sales levels in the final environmental impact statement for the water marketing program from Green Mountain Reservoir, Colorado (USDI/BR, 1985). For the water marketing EIS, the Bureau of Reclamation Eastern Colorado Projects Office was responsible for developing and applying a computer model to support system-wide reservoir and river operations studies. That model has been adapted to permit an assessment of Rock Creek/Muddy Creek operations on the Colorado River and Blue River (see Sections 4.3.3 and 4.4.3). For impacts assessment, key reference gaging stations are the Colorado River at Kremmling and Dotsero and the Blue River below Green Mountain Reservoir.

The study period for the Bureau's system-wide operational analysis was the 19 water years 1964-1982 (Oct. 1, 1963 through Sep. 30, 1982). The operations studies considered the historic operations during this period, corrected to reflect full utilization of Denver's Dillon Reservoir-Roberts

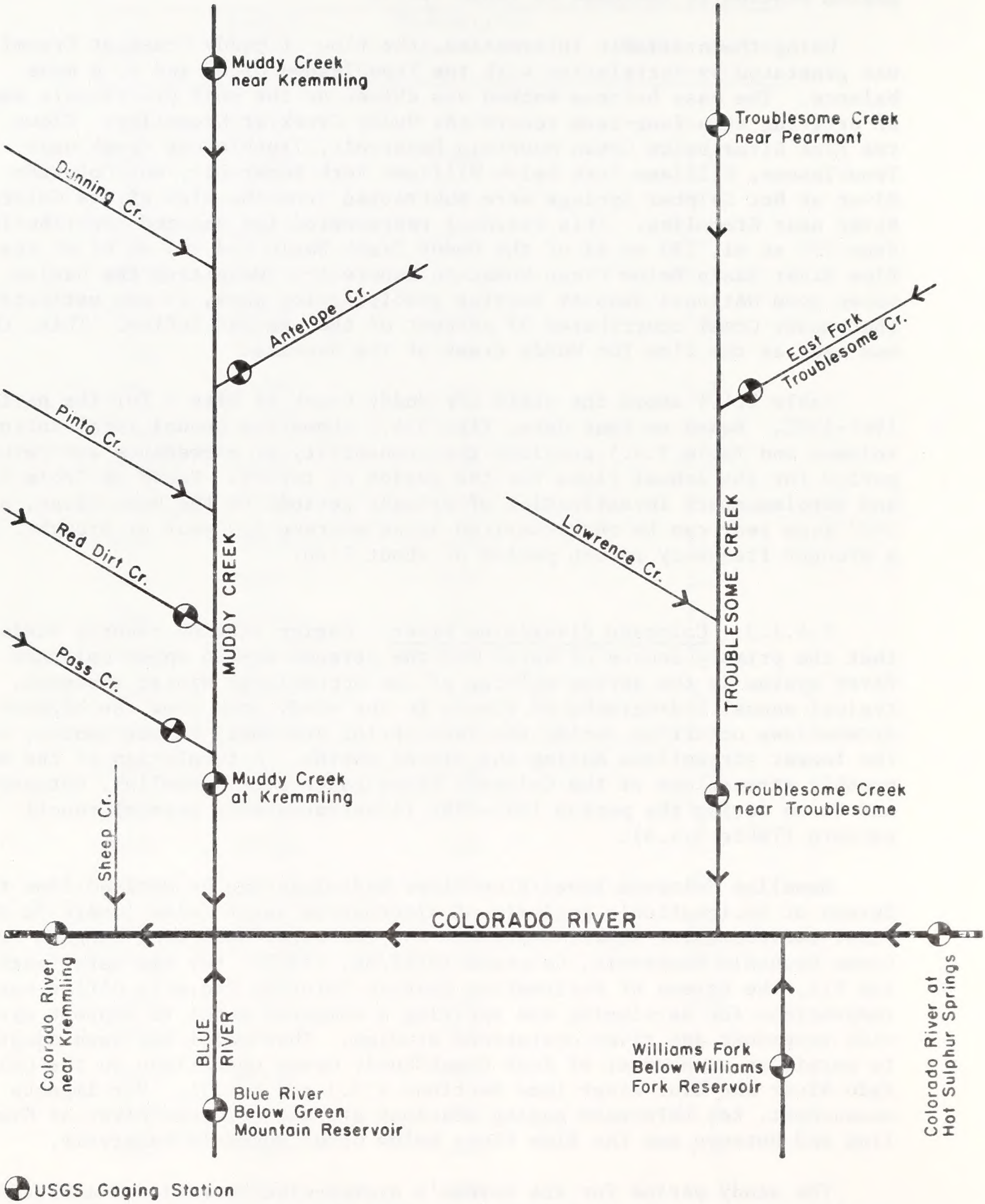


Fig. 3.4.3. Schematic diagram of gaging stations near Kremmling

FIGURE 3.4.4.

PERIOD OF RECORD AT GAGING STATIONS NEAR KREMMLING

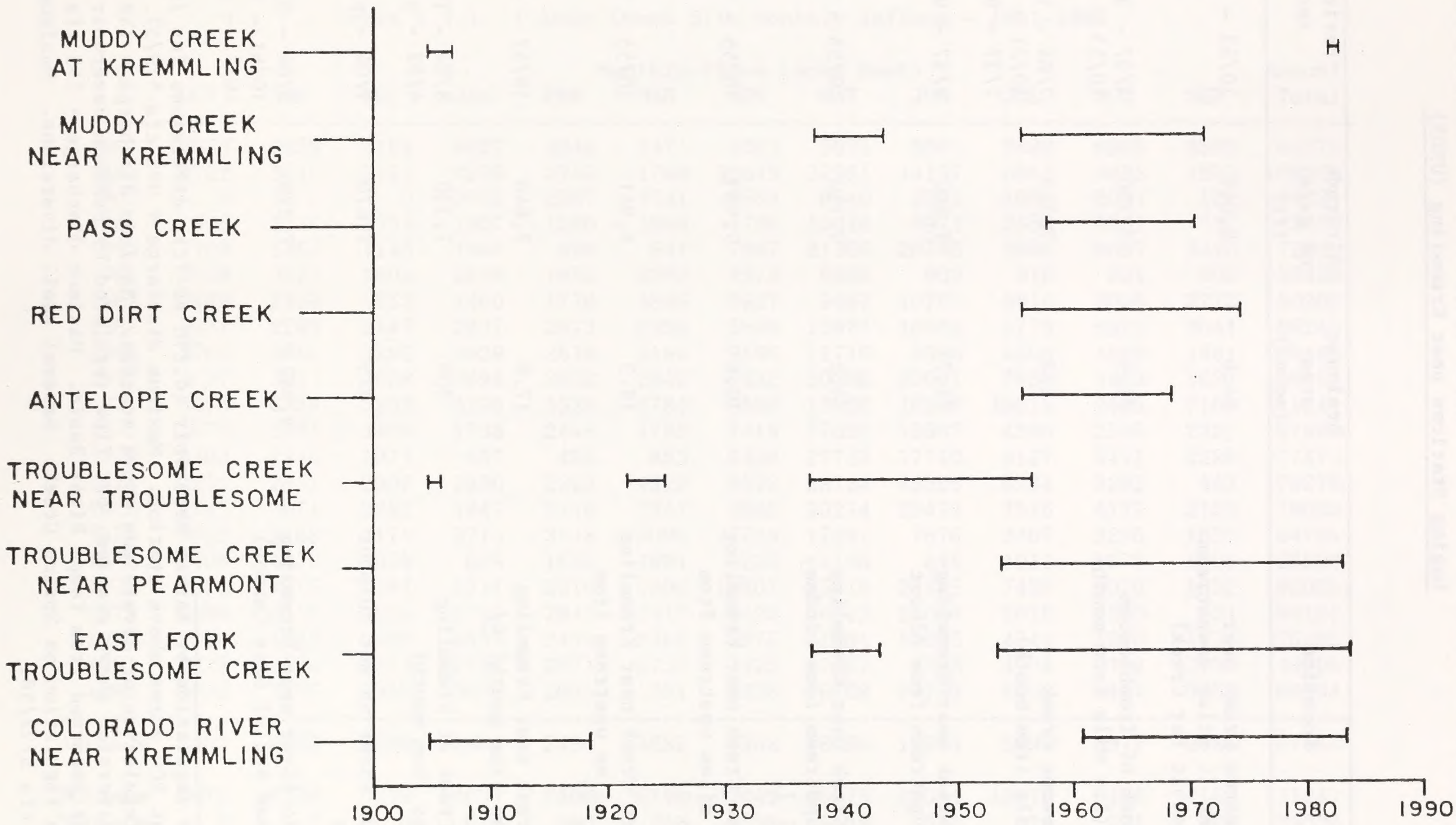


Table 3.4.3
Gaging Stations near Kremmling (USGS)

Location	Drainage area (sq mi)	Altitude of gage (ft)	Period of record
Troublesome Creek near Pearmont (4 miles downstream from Rabbit Ear Creek)	44.6	8,049	10/53 - present
East Fork of Troublesome Creek (1.4 mile from mouth)	81.4	7,750	4/37 - 9/43 10/53 - present
Troublesome Creek (1/2 mile from mouth)	178	7,344	7/04 - 10/05 10/21 - 9/24 7/37 - 9/56
Muddy Creek near Kremmling (just upstream from Albert Creek)	71.7	7,800	9/37 - 9/43
Muddy Creek near Kremmling (just upstream from Lindsey Creek) 1/	74.2	7,750	10/55 - 9/71
Antelope Creek near Kremmling (5-3/4 miles upstream from mouth) 2/	10.6	7,933	10/55 - 9/68
Red Dirt Creek near Kremmling (9-1/4 miles upstream from mouth) 3/	18.3	8,961	10/55 - 9/74
Pass Creek near Kremmling (6 miles from mouth) 4/	17.8	7,840	10/57 - 9/70
Muddy Creek at Kremmling (2 miles from mouth)	300	7,330	8/04 - 10/06 4/82 - present
Colorado River at Hot Sulphur Springs	825	7,670	7/04 - present
Colorado River near Kremmling (upstream end of Gore Canyon)	2,382	7,320	7/04 - 9/18 10/61 - 9/70 10/71 - present

1/ Some regulation by Barber Reservoir (4,290 ac-ft), diversions for irrigation of about 900 acres above station. Maximum discharge = 992 cfs 5/9/57.
2/ No regulation or diversions above station. Maximum discharge = 148 cfs 3/27/60.
3/ No diversion above station, but flow regulated by McMahon Reservoir 4,500 ac-ft water imported from Yampa River Basin. Maximum discharge = 343 cfs 6/13/57.
4/ Some regulation on Spring Creek. Several small diversions. Maximum discharge = 107 cfs 5/22/58.

Table 3.4.4. Muddy Creek Site Monthly Inflows - 1961-1982

Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual Total
	Monthly Flows (Acre Feet)												
1961	4653	3859	5164	6627	4846	3471	4023	5075	3587	5499	6965	6505	60275
1962	4722	3610	2151	3259	2753	1760	32049	32951	14157	6663	3633	1850	109559
1963	0	0	0	2082	2587	4731	6569	8840	2251	1050	2054	121	30284
1964	966	1647	1354	1307	1260	1669	4736	12348	8971	3558	5331	732	43879
1965	1109	1362	1145	1064	998	941	7957	21366	20785	5986	6087	3420	72220
1966	3708	3227	1603	2688	1652	3950	4573	6686	903	316	221	902	30429
1967	2469	2538	1553	1460	1776	4895	5927	9467	10707	3610	3026	2772	50200
1968	1931	2289	2147	2837	2873	2998	5889	12877	16658	5778	6923	3044	66245
1969	2768	3822	3292	3029	2616	3190	9599	11710	8580	4208	1068	1581	55463
1970	4697	3617	3528	3694	2668	3849	9432	30386	20691	7658	4563	1681	96463
1971	6076	6359	5239	5195	5538	6784	8599	13026	18228	19612	9425	7160	111241
1972	3873	2595	3409	1738	2448	4783	7319	17020	15567	4390	2535	2322	67998
1973	3403	2346	1074	657	485	853	6358	27733	17740	9127	5471	2226	77473
1974	2270	2871	2902	2930	2223	4922	8522	28724	13395	6784	3292	443	79278
1975	2747	3071	2282	1847	2116	2947	5882	20274	23472	7515	4777	2153	79083
1976	3022	3468	4171	3713	3148	5096	7723	17937	7876	3467	3296	1850	64766
1977	2408	1870	3029	628	1656	1994	5259	4138	845	1011	1677	1023	25538
1978	2220	1915	1484	2411	2216	4400	10907	25519	23485	7426	3026	1052	86060
1979	2656	3110	3836	3149	2943	2417	9023	36715	25084	5616	4370	234	99151
1980	1660	2823	2326	2835	2494	2368	8975	31501	10085	4744	4840	1835	76485
1981	2875	2720	2311	2199	2871	2730	3425	7067	4383	4704	2492	2130	39906
1982	3630	3257	2970	3690	2695	1451	2558	16608	17756	6502	2424	3053	66594
Average	2903	2835	2590	2684	2494	3282	7968	18090	12964	5692	3977	2186	67663
Maximum	6076	6359	5239	6627	5538	6784	32049	36715	25084	19612	9425	7160	111241
Minimum	0	0	0	628	485	853	2558	4138	845	316	221	121	25538

Fig. 3.4.5. MUDDY CREEK SITE INFLOWS

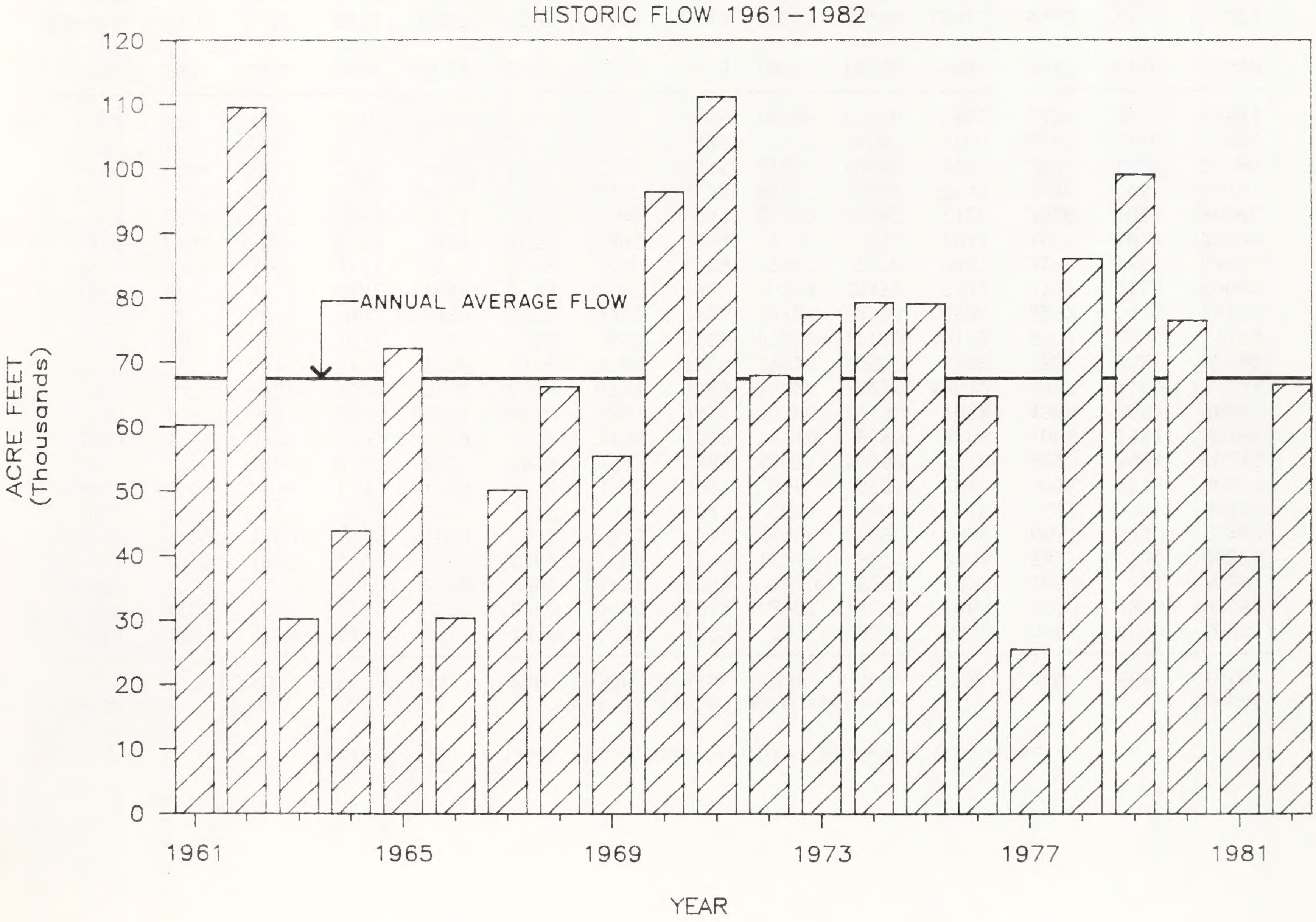


Table 3.4.5
Muddy Creek Annual Inflow Frequency Analysis

Year	Annual flow (ac-ft)	Probability of exceedance	Return period (yrs)
1961	60275	.652	1.5
1962	109559	.087	11.5
1963	30284	.913	1.1
1964	43879	.783	1.3
1965	72220	.435	2.3
1966	30429	.870	1.2
1967	50200	.739	1.4
1968	66245	.565	1.8
1969	55463	.696	1.4
1970	96463	.174	5.8
1971	111241	.043	23.0
1972	67998	.478	2.1
1973	77473	.348	2.9
1974	79278	.201	3.8
1975	79083	.304	3.3
1976	64766	.609	1.6
1977	25538	.957	1.0
1978	86060	.217	4.6
1979	99151	.130	7.7
1980	76485	.391	2.6
1981	39906	.826	1.2
1982	66594	.522	1.9
Mean flow for period of record -- 67,663 ac-ft			

Table 3.4.6

Historic Flows at Selected Colorado River Gaging Stations (1962-1982) in 1000 Acre-Feet

Location Colorado River near:	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Kremmling	46.16	38.36	34.40	33.20	30.87	38.85	57.15	110.13	109.38	81.38	60.22	49.13
Dotsero	79.68	67.44	59.17	55.94	53.23	66.05	104.22	264.22	320.57	174.65	101.56	80.46
Cameo	137.25	120.18	109.66	102.14	92.84	113.42	175.80	476.07	641.26	337.02	164.12	133.33

Tunnel water rights, and evaluated the zero sales condition and sales levels from Green Mountain Reservoir of 22,800 acre-feet and 28,800 acre-feet annually. The Bureau has selected a sales level of 22,800 acre-feet as its preferred alternative for water marketing. The hydrology model utilizes historical data which are modified by removing historical Blue River operations and adding back in the simulated Blue River operations. The water sales demand level, release pattern, and flow depletions were based on the consolidation and summary of data submitted by requestors for long-term water sales contracts as provided by the Colorado River Water Conservation District. (USDI/BR, 1985)

Appendix D of the Green Mountain EIS contains a line-by-line summary of the operation and mean monthly flows for the zero, 22,800 acre-feet, and 28,800 acre-feet sales levels for the period 1962-1982. Table 3.4.7 summarizes that data for the period of record for the Blue River (below Green Mountain Reservoir) and the Colorado River (near Kremmling and Dotsero). Data are presented for a zero sales (simulated historic) condition, for the Bureau's preferred alternative sales level of 22,800 acre-feet, and for a maximum sales level of 28,800 acre-feet.

The simulated historic (zero) sales level represents the flows of record experienced at these gaging stations as modified by the assumptions of the Green Mountain simulation model. Actual historic flows at these gages are used in Chapter 4 (Sections 4.3.3 and 4.4.3) as a basis for comparison for impacts assessment. The flows for a Green Mountain sales level of 22,800 acre-feet represent simulated flow conditions given the assumptions of the Green Mountain model, including full use of Denver's Dillon Reservoir - Roberts Tunnel water right. This latter flow condition is used as a simulated baseline for purposes of impacts assessment in Chapter 4.

3.4.2. Downstream Channel Hydraulics

3.4.2.1. Rock Creek. For the Rock Creek project, two alternative reservoir sites are under consideration. The upper site (Site A) is located just below Horse Creek while the lower site (Site B) is near the entrance of a steep canyon about 3,000 feet below Site A (see Fig. 2.1). Differences in channel slope immediately downstream of each proposed reservoir site (see Fig. 3.4.6) contribute to substantially different channel hydraulics and flow regime under existing conditions. Based on the USFS stream classification procedure, the reach immediately below Site A is a C3 reach while the reach below Site B is a B1 reach. A C3 reach is a relatively mild sloped, gravel bed channel of moderately high sinuosity, while a B1 reach is a steep, relatively straight channel composed of large cobbles to small boulders. A C3 reach is relatively more sensitive to change than a B1 reach which is inherently more stable.

At the USGS stream gaging station at Toponas (upstream of Site A) the maximum recorded discharge between 1952 and 1980 was 494 cfs. About 80 percent of the annual flow occurs during the spring months as a result of snowmelt runoff (Butler, 1986). Approximately 500-700 acre-feet of average

Table 3.4.7

Hydrologic Summary Data for Key Colorado River/ Blue River Gaging Stations for Various Water Marketing Sales Levels from Green Mountain Reservoir (Simulated Operations 1962-1982 Water Years)

Gaging Station	Water sales level (ac-ft)	Oct 1-15	Oct 16-31	Nov	Dec	Jan	Feb	Mar	Apr 1-14	Apr 15-30	May	Jun	Jul	Aug	Sep
		1962-1982 Water Years (1000 ac-ft)													
Blue River below Green Mountain Reservoir	0.0	8.42	11.29	21.01	22.39	22.39	16.79	12.84	6.59	4.50	5.84	6.92	15.83	17.99	17.01
	22.8	9.04	10.71	19.91	21.11	21.05	16.05	12.35	7.09	4.97	5.34	6.49	15.45	20.27	18.96
	28.8	9.20	10.50	19.64	20.84	20.78	15.92	12.31	7.24	5.07	5.18	6.31	15.70	20.96	19.29
Colorado River near Kremmling	0.0	18.40	24.06	42.23	40.00	39.27	32.36	32.67	22.42	23.74	69.36	64.37	55.37	47.94	40.51
	22.8	19.18	23.31	40.52	38.14	37.62	31.42	32.08	22.90	24.21	68.89	63.99	54.90	49.34	42.22
	28.8	19.40	23.16	40.25	37.87	37.35	31.28	32.04	23.06	24.30	68.73	63.81	55.15	50.04	42.65
Colorado River near Dotsero	0.0	35.80	40.18	71.31	64.77	62.01	54.72	59.88	35.38	57.84	223.45	275.57	148.65	89.29	71.84
	22.8	36.53	39.38	69.10	62.46	59.97	53.62	59.21	35.83	58.29	223.19	275.64	148.30	90.36	73.42
	28.8	36.68	39.18	68.30	61.70	59.27	53.32	59.09	35.95	58.36	223.02	275.45	148.51	90.72	73.71

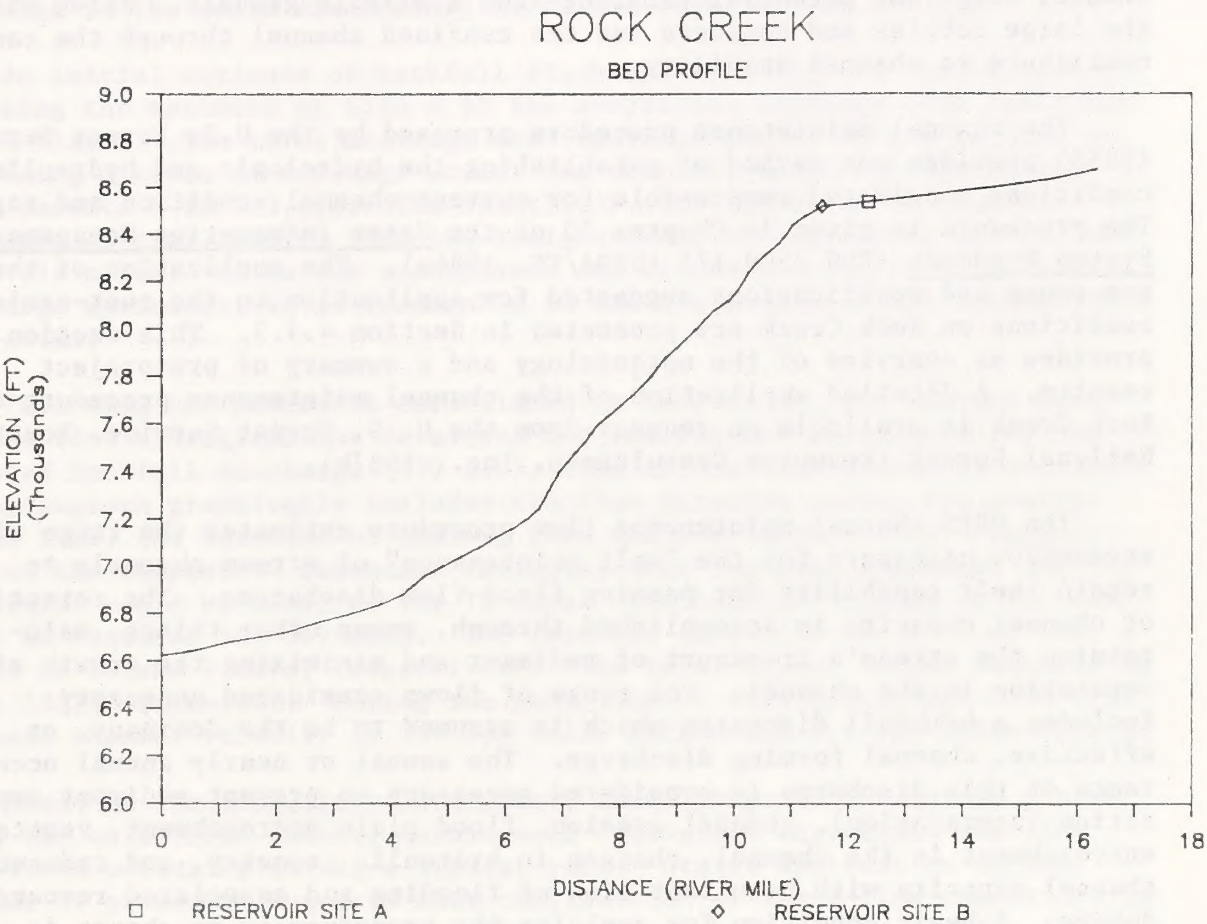


Fig. 3.4.6. Rock Creek bed profile

annual inflow has been predicted to accrue from vegetative treatment (USDA/FS, 1983). Sediment sampling from 1976 to 1985 at the gage (see Butler, 1986) found that the mean annual bed load and suspended load were approximately equal (230 and 190 tons/day, respectively) and that there was insignificant wash load (i.e., silts and clays).

Current channel conditions immediately below both reservoir sites are considered stable. This assessment is supported by the observed insignificant channel erosion and sediment transport occurring and the limited impact of man's activities (primarily small scale grazing and timber harvesting). Stability below Site A is the result of the mild channel slope and potential armoring from available gravels. Below Site B the large cobbles and boulders and the confined channel through the canyon contribute to channel stability.

The channel maintenance procedure proposed by the U.S. Forest Service (USFS) provides one method of establishing the hydrologic and hydraulic conditions considered responsible for current channel condition and regime. The procedure is given in Chapter 30 of the Water Information Management System Handbook (FSH 2509.17) (USDA/FS, 1986a). The application of the procedure and modifications suggested for application to the post-project conditions on Rock Creek are presented in Section 4.3.3. This section provides an overview of the methodology and a summary of pre-project results. A detailed application of the channel maintenance procedure to Rock Creek is available on request from the U. S. Forest Service, Routt National Forest (Resource Consultants, Inc., 1987b).

The USFS channel maintenance flow procedure estimates the range of streamflow necessary for the "self maintenance" of stream channels to retain their capability for passing flood-flow discharges. The retention of channel capacity is accomplished through, among other things, maintaining the stream's transport of sediment and minimizing the growth of vegetation in the channel. The range of flows considered necessary includes a bankfull discharge which is assumed to be the dominant, or effective, channel forming discharge. The annual or nearly annual occurrence of this discharge is considered necessary to prevent sediment deposition (aggradation), channel erosion, flood plain encroachment, vegetation encroachment in the channel, changes in hydraulic geometry, and reduced channel capacity with resultant risk of flooding and associated resource damage. A basic condition for applying the procedure is no change in upstream sediment supply from pre- to post-project conditions.

The first step in the USFS procedure is determination of the bankfull discharge at the point of quantification. The point of quantification is that location (or reach) where prevention of aggradation or vegetation encroachment is judged to be most critical to maintaining channel capacity. Determination of bankfull can be based on field observations, stream gaging data or a flood frequency curve.

Analysis of bank full discharge in the reach near the Toponas stream gaging station (upstream of Site A) indicated that the most representative bankfull discharge for this reach of Rock Creek was 173 cfs, which corresponds to a flow depth of 2.6 feet at the gage and 2.5 feet at a cross

section downstream of the gage. From the flood frequency curve, 173 cfs corresponds to about a 1.06-year event. It is important to note that this result is representative of a reach of the channel, not a single point in the reach.

To accurately reflect conditions at the point of quantification below Site A, the bankfull estimate near the gage needs to be adjusted to reflect the additional drainage area contributing to the reach below the reservoir. The drainage area at the gage, which is upstream of the dam and Horse Creek, is 47.6 sq. mi. The total drainage area contributing to the reservoir is about 52.2 sq. mi. Using a ratio of drainage areas, the bankfull discharge in the reach immediately below the reservoir is 190 cfs.

An initial estimate of bankfull discharge below Site B can be made by adjusting the estimate at Site A by the additional drainage area contributing to Site B. The total drainage area contributing to Site B is 52.9 sq. mi. Using a ratio or drainage areas, the bankfull discharge immediately below damsite B is 193 cfs. The relatively minor increase in bankfull discharge (3 cfs) results from the insignificant drainage area between the reservoir sites. Given the assumptions and relative accuracy of bankfull discharge estimates, it is reasonable to use the same bankfull estimate for both sites.

Following the procedure established in Chapter 30, the channel maintenance flow hydrograph was developed for pre-project conditions for the selected bankfull discharge (190 cfs). The information needed to construct the hydrograph graphically includes the flow duration curve, the average annual flow, the baseflow or thalweg flow and the minimum flow. Application of the Chapter 30 procedure indicates that the peak bypass of 190 cfs (bankfull) would be required for 16 days. The baseflow bypass of 3.5 cfs would be required for 319 days. The rise and recession would occur over a period of 20 and 9 days, respectively. The total bypass volume required is about 13,200 acre-feet. During the peak flow of this hydrograph (190 cfs) the mean channel velocity is 3.7 fps below Site A and 8.2 fps below Site B.

Based on the assumptions and theory underlying the Chapter 30 procedure, the calculated channel maintenance hydrograph represents the flow conditions occurring during a typical year. Strict application of the Chapter 30 procedure suggests that continuation of these flow conditions is necessary for self-maintenance of the existing channel (see Section 4.3.3 for application of the procedure to Rock Creek for post-project conditions and development of recommended channel maintenance flow requirements).

To illustrate the significance of the channel maintenance flow requirements obtained by a strict application of Chapter 30, the derived hydrograph was superimposed on the 1980 water year hydrograph (Fig. 3.4.7). The 1980 water year was selected for comparison since it produced a total flow at the gage of 23,630 acre-feet, approximately equal to the average annual yield of 23,890 acre-feet at the gage or about 27,000 acre-feet at the point of quantification. It is important to note that the total volume of water required for channel maintenance under a strict application of Chapter 30 is about 50 percent of the average annual yield (see Section 4.3.3 for recommended post-project requirements).

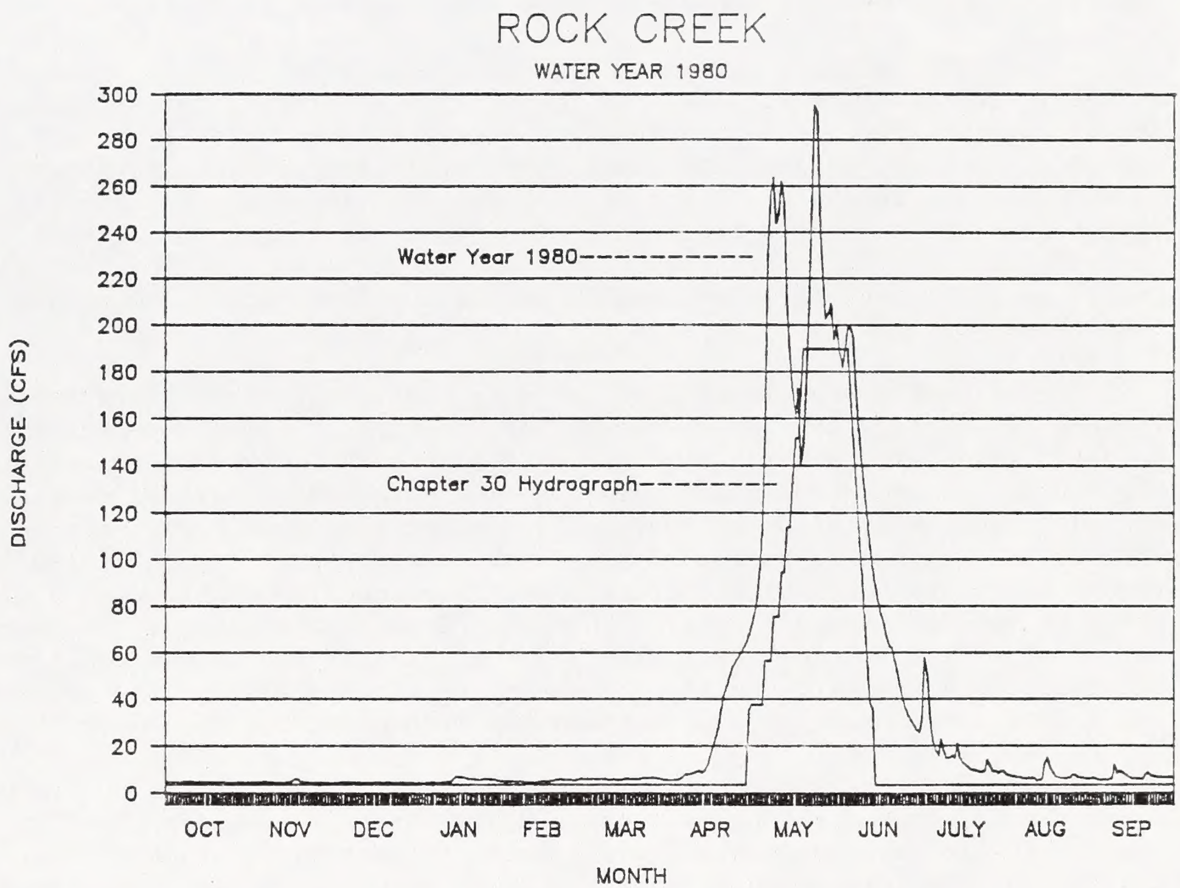


Fig. 3.4.7. Chapter 30 channel maintenance hydrograph superimposed on water year 1980 hydrograph

3.4.2.2. Muddy Creek. Muddy Creek flows through land under the jurisdiction of the Bureau of Land Management (BLM). Therefore, application of the Forest Service Chapter 30 procedure to Muddy Creek was not required under pre- or post-project conditions. An application under pre-project conditions, similar to that discussed above for Rock Creek, might have provided insight on annual hydrologic and hydraulic conditions; however, available data were limited and results obtained were considered inconclusive. Adequate information on existing hydraulic conditions was obtained from simpler, more direct approaches.

Overall, Muddy Creek below Site C is classified as a C5 reach based on the USFS stream classification procedure. A C5 reach is a channel of mild slope and high sinuosity in a silt/clay bed with some fine to medium sands. An additional unique feature in Muddy Creek below Site C is the occurrence of short reaches armored with large gravels and small cobbles. These reaches were typically 100-200 feet in length separated by long reaches that more accurately fit the C5 description. This situation is similar to the Colorado River below Glen Canyon Dam where channel stability is controlled by 10 gravel-cobble bars in the 24-km reach below the dam (Pemberton, 1976). The absence of significant vertical instability in Muddy Creek suggests that similar to the Colorado River below Glen Canyon Dam, the gravel-cobble bars are providing vertical control in Muddy Creek.

An additional factor promoting channel bed stability below Site C is the extremely mild channel slope (see Fig. 3.4.8). In the reach below Site C the channel slope is only 2 to 3 feet per mile. The rather abrupt change in slope between the upper and lower watershed also suggests that reach below Site C is a natural zone of aggradation for sediments eroded and transported from the upper watershed. This aggradation would minimize degradation problems, but could promote lateral instability as a result of bar formations deflecting current into the channel banks.

Gaging station data are available at five locations in the Muddy Creek drainage. The main stem gage nearest the point of quantification is Muddy Creek at Kremmling (09041500). The gage is located about 2.8 miles upstream of the mouth and drains an area of about 290 sq. mi. The USGS has collected discharge data at this gage since April 1982 (limited data are also available for 1904 and 1905). For the more recent period of record the maximum discharge of 1,670 cfs occurred during May 1984 and produced a mean velocity of about 3.5 fps. Over 70 percent of the annual flow of Muddy Creek occurs during the spring months as a result of snowmelt runoff (Ruddy, 1986). During 1985 the USGS collected sediment discharge data at the gage and concluded that over 97 percent of the total sediment load is suspended load. Furthermore, of the suspended load prior to the snowmelt peak over 90 percent was silts and clays while after the peak over 80 percent was silts and clays (Ruddy, 1986).

The type of channel and nature of the suspended load suggest that Muddy Creek can be classified as a suspended load channel according to an alluvial channel classification scheme proposed by Schumm (1977). In this classification system, a stable suspended load channel is generally narrow, deep and sinuous with a width/depth ratio less than 10, a sinuosity greater than 2 and a relatively gentle gradient. Muddy Creek below Site C is

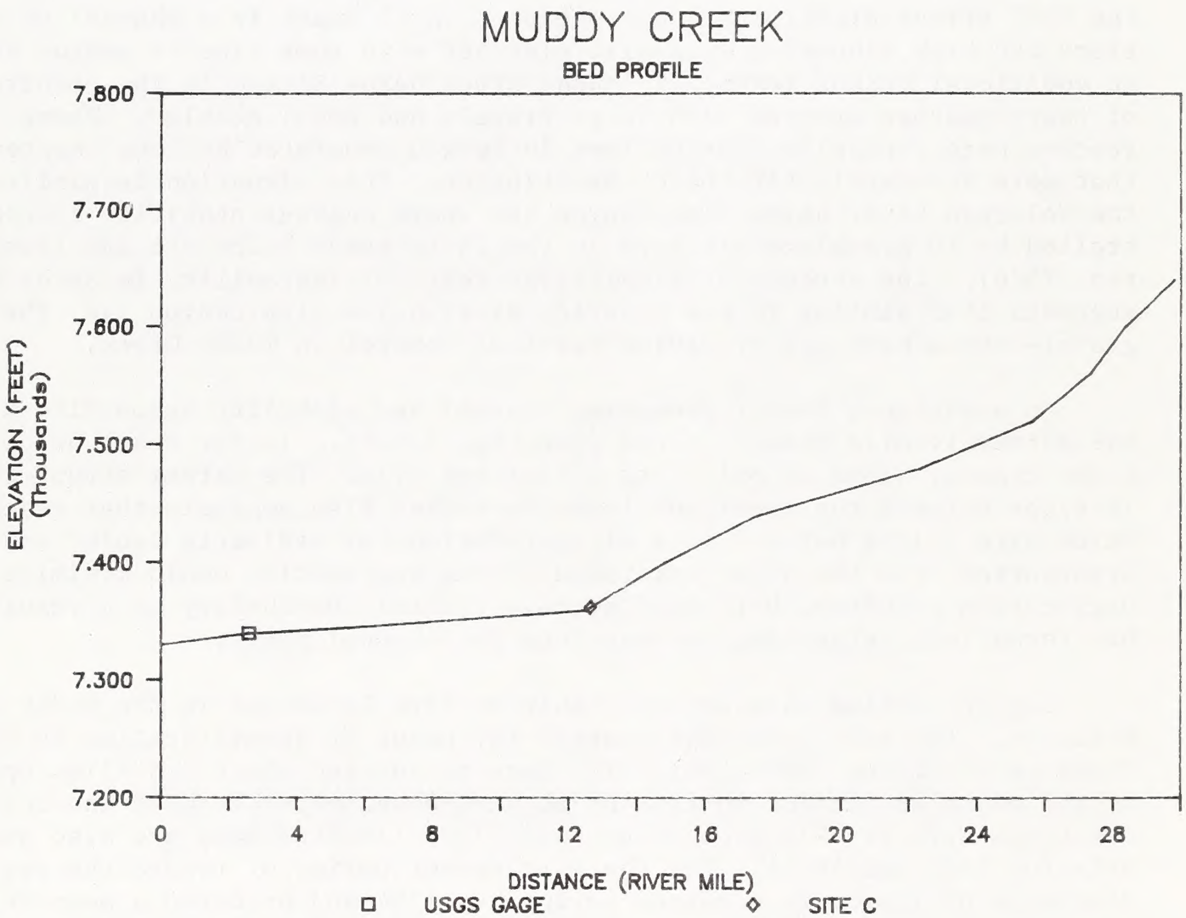


Fig. 3.4.8. Muddy Creek bed profile

currently sinuous and mild sloping; however, in general the channel is not narrow and deep, but rather relatively wide and shallow with a width/depth ratio typically greater than 10. Therefore, one can conclude that the channel is not currently stable or in equilibrium, but rather is adjusting, perhaps to the effects of grazing (see Section 3.11.2).

3.4.3. Water Quality. The Federal Water Pollution Control Act Amendments of 1972 (PL 92-500) gave the Federal Government, through the Environmental Protection Agency, the dominant role in directing and defining water pollution control programs across the country. The objective of this act was to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. Water quality standards have been developed on a state-by-state basis after EPA approval in an attempt to monitor the maintenance or improvement of surface-water quality. The Colorado State water quality standards are based on surface-water classification. In Colorado, the Department of Health is responsible for standard promulgation and monitoring efforts. Such State standards are to include both beneficial uses and criteria necessary to protect those uses, as well as an antidegradation policy consistent with Federal requirements.

The overall surface-water quality in the Colorado River basin in Colorado is good. There are a few exceptions when streams flow through geologic formations containing soluble calcium and sulfate (gypsum) (USDI/BLM, 1984).

Water pollution is not a large-scale problem in the study area. The only point sources of pollution along the Colorado and its tributaries are municipal waste plants. Nonpoint source pollution is common in the form of agricultural runoff. This type of pollution may contribute nitrogen and suspended sediments to the surface waters (USDI/BLM, 1984).

Springs were sampled as part of a surface water inventory in 1980. With the exception of a few springs that were highly saline, the springs generally had good water quality (USDI/BLM, 1984). Much of these data were from one-time field checks and did not identify seasonal or annual variations in water quality.

3.4.3.1. Rock Creek. Rock Creek water quality was characterized using unpublished data from the U.S. Geological Survey and the U.S. Forest Service. These data include U.S. Geological Survey sampling programs at the Toponas gage, the Crater gage, and McCoy. The U.S. Forest Service data base was approximately 10 years of data with 63 records of mostly physical parameters at McCoy. Statistical analyses were limited, yet still provided an overall picture of water quality for Rock Creek at Toponas (Table 3.4.8).

The State of Colorado Department of Health (CDOH, 1986) has classified the surface waters of Rock Creek as:

Class 1 Recreation
Class 1 Cold water aquatic life
Water supply
Agricultural

Table 3.4.8

Rock Creek Water Quality Characterization at Toponas

Variable	Mean	Standard Error	Sample size
Specific conductance (micro Siemen/cm)	68	12	67
Dissolved oxygen (mg/L)	8.7	0.6	10
pH (standard units)	7.2	0.05	41
Total N (mg/L)	0.68	0.08	3
NH_4-N (mg/L)	0.02	0.007	3
NO_3-N (mg/L)	0.13	0.03	3
Total P (mg/L)	0.07	0.023	3
Ortho-P (mg/L)	0.01	0.003	3
Calcium (mg/L)	12.0	1.3	4
Magnesium (mg/L)	2.5	0.4	4
Sodium (mg/L)	2.9	0.4	4
Potassium (mg/L)	0.8	0.1	4
Sulfate (mg/L)	8.4	0.5	3
Chloride (mg/L)	0.9	0.1	3
Alkalinity (mg/L as $CaCO_3$)	38	5	4
Total dissolved solids (mg/L)	63	9	4

Numeric standards include dissolved oxygen no less than 6.0 mg/L, 7.0 mg/L during spawning periods; pH of 6.5-9.0; fecal coliform 200/100 mL. Inorganic standards are:

Unionized ammonia	0.02	mg/L
Residual chlorine	0.003	mg/L
Free cyanide	0.005	mg/L
Hydrogen sulfide	0.002	mg/L (undissociated)
Boron	0.75	mg/L
Nitrite	0.05	mg/L
Nitrate	10.0	mg/L
Chloride	250.0	mg/L
Sulfate	250.0	mg/L

There are numeric standards for 15 heavy metals. Water quality analyses for Rock Creek occasionally included heavy metal analyses and, in all cases, metal concentrations were well below water quality standards. Further, all water quality samples analyzed to date have met these State standards.

Rock Creek water quality at Toponas may be characterized as a calcium bicarbonate type water. Total dissolved solids averaged 63 mg/L for the period of record. The specific conductance averaged 68 microSiemens/cm. Cations in decreasing order were calcium, sodium, magnesium, and potassium, while anions in decreasing order were bicarbonate, sulfate, and chloride. Little turbidity was observed from suspended sediments, however color was observed. The color was not measured, but was attributed to the presence of organics from the decaying vegetation along the stream meanders and in beaver ponds. The stream meanders and beaver ponds were above the sampling station at Toponas. Dissolved oxygen remained near saturation even with the organic load. The average pH at Toponas was 7.2, which is within the water quality standard of 6.5-9.0. Heavy metals were not expected (Wentz, 1974) or routinely measured.

Nitrogen and phosphorus were higher at Toponas than at other stations on Rock Creek. The nitrogen and phosphorus are due to the meandering streams with willow plants as the riparian vegetation and the presence of beaver ponds. The color of Rock Creek supports the idea that organic nitrogen and phosphorus are present in these waters. The available data base did not allow assessment of seasonal variations in nutrient concentrations.

Additional water samples were taken during July and August 1986 from streams that are tributary to the proposed Rock Creek Reservoir basin. These streams included Horse Creek, Shoe and Stocking Creek, Jolley Creek, and Rock Creek at State Highway 134. Water quality samples taken from Shoe and Stocking and Jolley Creek were similar to Rock Creek at Toponas. Water quality samples from Horse Creek and particularly from Rock Creek at Highway 134 had lower nitrogen and phosphorus concentrations than Rock Creek at Toponas. Samples from Rock Creek at Highway 134 averaged approximately 60 percent of the dissolved solids as Rock Creek at Toponas.

The existing data base was inadequate to distinguish or separate individual stream contributions to the proposed Rock Creek Reservoir. Thus the water quality data base for Rock Creek at Toponas was used. It must be recognized that this data base has limitations but is the best presently available. Use of the data base at Toponas represents a worst case scenario and will provide a conservative estimate of potential water quality impacts.

Arithmetic means were calculated for the nitrogen and phosphurus species (Table 3.4.8). A sample size of 3 precludes calculating nutrient loadings using volume weighted concentrations or flow interval methods. Thus, the arithmetic mean was used with the average annual water yield to estimate nutrient loading. To identify the potential range of nutrient loading in the proposed reservoir, the mean concentration of each water quality parameter was also multiplied by the annual minimum and maximum water yield for the period of record (Table 3.4.9). The phosphorus flux was 2.3 Mg/yr and the nitrogen flux was 21.9 Mg/yr.

An attempt was made to characterize the annual temperature variation in Rock Creek, but meteorological data were not available for the immediate area. Data from Kremmling and Steamboat Springs were not representative of the study area.

Water temperature data from the USGS were summarized to characterize annual temperature variations in Rock Creek at Toponas. The average water temperature calculated by monthly means was 5.7°C, with a range of 0 to 26.5°C, given 125 measurements. The maximum temperature is probably closer to an observed value by the USGS of 20°C, since the 26.5°C measurement was probably an outlier. The water temperature is near 0°C from January 1 to about April 1, warming with longer days and warmer air temperatures. Maximum temperatures occur in late August and rapidly cool to 0°C by mid-November. During the winter months, the stream may be ice covered, but streamflow still occurs.

A small spring known as Iron Spring located near the confluence of Little Rock Creek and Rock Creek was also sampled. The Iron Spring (actually three springs located within a 2-meter radius) exhibited a bubbling action. Dissolved oxygen measurements were 1 mg/L or less. Hydrogen sulfide gas was not detected in any water quality sample. Standard analytical techniques for hydrogen sulfide have a detection limit of 1 mg/L. Alkalinity was over 800 mg/L as calcium carbonate, thus the bubbling gases were probably free carbon dioxide. Specific conductivities were usually above 1,000 microSiemens/cm. The cations in decreasing order were calcium, magnesium, sodium, and potassium. Anions in decreasing order were bicarbonate, sulfate, and chloride. Discharge was not measured at the Iron Spring.

3.4.3.2. Muddy Creek. Existing water quality of Muddy Creek was analyzed using data supplied by the USGS. Additional BLM data were for physical analyses only. Stream samples and discharge measurements were taken by the USGS between March 1985 and April 1986 at the USGS gaging station located on Muddy Creek near Kremmling, Colorado. Samples were taken monthly through most of the year with more frequent sampling occurring during the spring runoff. Additional water samples were taken in July

Table 3.4.9
Calculated Streamflow Flux (Mg/yr) for Selected Constituents for Rock Creek at Toponas

Variable	Mean calculation	Average flux	Period of Record Maximum	Minimum
Total N	arithmetic	21.9	39.5	7.9
NH4-N	arithmetic	0.6	1.2	0.2
NO3-N	arithmetic	4.2	7.5	1.5
Total P	arithmetic	2.3	4.1	0.8
Ortho-P	arithmetic	0.3	0.6	0.1
Calcium	arithmetic	386	700	140
Magnesium	arithmetic	80	145	29
Sodium	arithmetic	93	170	34
Potassium	arithmetic	26	46	9
Sulfate	arithmetic	270	490	97
Chloride	arithmetic	29	52	10

and August 1986. Samples were analyzed for their physical and chemical characteristics and summary statistics were calculated (Table 3.4.10).

The State of Colorado Department of Health (CDOH, 1986) has classified the surface waters of Muddy Creek as:

Class 2 Recreation
Class 1 Cold water aquatic life
Water supply
Agriculture

Numeric standards include dissolved oxygen not less than 6.0 mg/L, 7.0 mg/L during spawning periods, pH of 6.5-9.0, and fecal coliform 2000/100 mL. Inorganic standards are the same as for Rock Creek. Heavy metal standards are similar to Rock Creek, with several variables having lower standards (higher allowable concentrations) given the change in surface-water classification (Class 2 versus Class 1 recreation).

The water quality data base used to characterize Muddy Creek included several samples that exceeded State water quality standards. The pH standard was exceeded once, a sample with pH 9.2. The sulfate standard of 250 mg/L was exceeded in 6 of the 13 water quality samples. No heavy metal concentration exceeded the water quality standards in this data base.

Water quality standard violations (when water quality concentrations exceed State water quality standards) have not been attributed to any specific land use activity. It appears that the geologic input dominates surface-water chemistry.

Muddy Creek at the Kremmling gaging station may be characterized as a calcium sulfate type water. The cations in decreasing order were calcium, sodium, magnesium, and potassium, while the anions in decreasing order were sulfate, bicarbonate, and chloride. The specific conductance averaged 669 microSiemens/cm and TDS averaged 500 mg/L. Both nitrogen and phosphorus had higher concentrations than Rock Creek but appear to be characteristic of the area.

The existing chemical nature of Muddy Creek is reflective of the local geology and soils. Cations were dominated by calcium, magnesium, and sodium. These cations were present in levels significantly higher than the other cations, resulting from the chemical and physical weathering of geologic materials in the watershed. Parent materials are predominantly Pierre and Mancos shales, both of which are marine shales with calcareous sandstone formations (Tweto, 1976). Such marine formations weather to yield significant amounts of calcium and sodium (Hem, 1985). The watershed also contains several igneous dikes and formations containing volcanic ashes (Tweto, 1976). Such igneous formations contain mafic minerals which weather to yield magnesium (Hem, 1985). Concentrations of calcium and magnesium convert to a hardness of 147 mg/L as calcium carbonate which gives the water a hard classification (EPA, 1976). Occasionally water samples were analyzed for heavy metals. No heavy metal problems have been identified in Muddy Creek. Samples are generally not analyzed for heavy metal concentrations. Given the slightly alkaline pH of the system, it can be assumed metals, if present, have low concentrations often below analytical detection limits (Wentz, 1974).

Table 3.4.10

Muddy Creek Water Quality Characterization

Variable	Mean	Standard error	Sample size
Specific conductance (micro Siemen/cm)	669	98	40[1/]
Dissolved oxygen (mg/L)	9.0	0.3	13
pH (standard units)	8.20	0.09	25[1/]
Total N (mg/L)	1.500	0.163	13
NH_4-N (mg/L)	0.100	0.021	13
NO_3-N (mg/L)	0.192	0.043	13
Total P (mg/L)	0.208	0.046	13
Ortho-P (mg/L)	0.050	0.050	13
Calcium (mg/L)	71.5	8.8	13
Magnesium (mg/L)	31.7	5.4	13
Sodium (mg/L)	39.5	7.5	13
Potassium (mg/L)	3.2	0.5	13
Sulfate (mg/L)	242.5	43.2	13
Chloride (mg/L)	4.9	1.0	13
Alkalinity (mg/L as $CaCO_3$)	139	10	13
Total dissolved solids (mg/L)	500	80	12

[1/] Includes water quality data from BLM.

Alkalinity in Muddy Creek is moderate at 139 mg/L as calcium carbonate, giving the stream a moderate acid buffering capacity. Given the average pH of 8.20, alkalinity is primarily due to the bicarbonate ion (Snoeyink and Jenkins, 1980). The bicarbonate results from geologic weathering and the natural exchange of atmospheric carbon dioxide with aqueous carbon dioxide (Hem, 1985).

The higher nitrogen and phosphorus concentrations may be from natural background sources. Unlike Rock Creek, riparian vegetation is often sparse along the main channel of Muddy Creek. Cattle grazing does occur along Muddy Creek and its tributaries. Cattle are often concentrated near the water and some nitrogen and phosphorus may be due to this land use activity, however an exact contribution was not determined.

The tributaries and Muddy Creek above the proposed reservoir were sampled for water quality to determine their relative nutrient input to the proposed reservoir. Tributaries included Cow Gulch and Antelope Creek. Muddy Creek was sampled above the confluence with Antelope Creek. Given Bureau of Land Management unpublished data and these additional samples, general observations were made on tributary water quality. Cow Gulch was observed to have lower streamflow and lower dissolved solids than Muddy Creek above Antelope Creek or Antelope Creek. Muddy Creek above Antelope Creek had lower TDS than Antelope Creek or Muddy Creek at Kremmling. Thus, using the water quality data base at Muddy Creek at Kremmling for water quality characterization will provide a conservative estimate.

Muddy Creek waters appeared turbid at all sampling times. The underlying fine-textured shales weather easily, contributing dissolved constituents as well as suspended materials to the surface waters. Turbidity and suspended sediment generally increased with increased streamflow.

Annual water temperature as calculated by monthly means was 7.1°C for Muddy Creek at Kremmling, with a minimum of 0°C and a maximum of 20°C, given 58 measurements. The water temperature is near 0°C until around mid-March and warms to a maximum around early August. Temperatures cool rapidly with the shorter fall days and reaches near freezing temperatures around early December.

Statistically significant relationships between constituent concentrations and stream discharge were determined for certain constituents. Through regression analysis, total nitrogen, calcium, magnesium, sodium, sulfate, and alkalinity were determined to be strongly related to discharge.

These relationships are important in determining the annual streamflow flux used to estimate nutrient loading rates in the reservoir. A significant relationship between stream discharge and nutrient concentrations justified using flow-weighted means to calculate nutrient loading rates. Preliminary calculations showed that there were no significant concentration differences between flow-weighted means and the more accurate flow interval method, largely because the sample size of 13 does not allow for rigorous statistical comparisons. Thus, flow-weighted means were used to estimate nutrient loading rates. If the water quality concentrations were

not significantly related to streamflow, the arithmetic or geometric mean was used. The arithmetic mean was used if the data were approximately normally distributed and the geometric mean if the data were lognormally distributed. The streamflow flux calculated for selected constituents for Muddy Creek is given in Table 3.4.11. The phosphorus flux was 3.9 Mg/yr and the nitrogen flux was 44.7 Mg/yr.

3.4.3.3. Colorado River. Water quantity and quality data are routinely collected from the Colorado River at several points including Dotsero and Hot Sulphur Springs by the U. S. Geological Survey. These data were used to characterize the water quality in the Colorado River near the study area. Colorado River water quality at Hot Sulphur Springs may be characterized as a calcium bicarbonate type water. The average annual water temperature was 6.9°C, and total dissolved solids (TDS) averaged approximately 90mg/L. Cations in decreasing order are calcium, sodium, magnesium, and potassium. Anions in decreasing order are bicarbonate, sulfate, and chloride.

The State of Colorado Department of Health (CDOH, 1986) has classified the surface waters of the Colorado River between the outlet of Lake Granby to State Bridge as:

Class 2 Recreation
Class 1 Cold water aquatic life
Water supply
Agriculture

Water quality standards are similar to those for Rock Creek (see Section 3.4.3.1).

The Colorado River water at Dotsero may also be classified as a calcium bicarbonate water. The average annual water temperature was 7.6 degrees and TDS averaged 250 mg/L. Cation and anion concentrations were greater than at Hot Sulphur Springs, but the order remained the same.

Given the slightly alkaline pH (7.5-8.1) and the turbidity in the Colorado River, heavy metal concentrations would not be expected to pose any problems for water use. Indeed, most metals would be near analytical detection limits.

Nitrogen and phosphorus concentrations are generally low in these waters. There are occasional inputs of nitrogen and/or phosphorus from irrigation return flows or from sewage treatment plants, nonetheless nitrogen and phosphorus concentrations remain low. Occasional water quality standard violations have been reported (USDI/GS, 1979).

Through the Kremmling area, the Colorado River water becomes more mineralized, as evidenced by the larger specific conductance values and sulfate concentrations. This area is underlain by Pierre Shale, parts of which are easily weathered (USDI/GS, 1979). Increased concentrations of total iron and suspended sediment in the Colorado River were attributed to Troublesome Creek as a result of natural runoff from iron-rich and easily eroded geologic formations (USDI/GS, 1979).

Table 3.4.11
Calculated Streamflow Flux (Mg/yr)
for Selected Constituents for Muddy Creek

Variable	Mean calculation	Average flux	Period of record Maximum	Period of record Minimum
Total N	Flow weighted	44.7	80.7	16.1
NH_4-N	Geometric	2.3	4.1	0.8
NO_3-N	Geometric	4.8	8.7	1.7
Total P	Geometric	3.9	7.0	1.4
Ortho-P	Arithmetic	1.6	2.9	0.6
Calcium	Flow weighted	1300	2340	466
Magnesium	Flow weighted	364	656	131
Sodium	Flow weighted	444	163	159
Potassium	Geometric	90	163	32
Sulfate	Flow weighted	2540	4580	912
Chloride	Flow weighted	58	105	21

3.5. Ground-Water Resources

3.5.1. Rock Creek. A general understanding of the ground-water resources in the Rock Creek valley can be obtained from published literature for the upper Colorado River basin (Iorns et al., 1965; Boettcher, 1972; Price et al., 1974) and from a USGS Water-Supply Paper covering the nearby Middle Park area (Voegeli, 1965). Specific reports are not available concerning just the hydrogeology of the Rock Creek area.

Springs are relatively common in the upper Colorado River basin (Iorns et al., 1965) and the Rock Creek area is no exception. The locations of numerous small springs are shown on the various USGS quadrangle maps covering the area. Some of the springs have been developed for stock-watering purposes. It is known that water from at least one spring, Iron Spring near the confluence of Little Rock and Rock creeks, has been used by local residents for drinking and culinary purposes.

The number of registered wells in the area is rather limited; in 1972 the density of wells ranged from 0 to 10 per township (Boettcher, 1972). The wells are probably used for just domestic and stock-watering purposes. Ground water is probably not used for irrigation due to the availability of surface water. The potential exists, however, for supplementary surface-water irrigation along the lower reaches of Rock Creek with well water from underlying and relatively permeable aquifers.

The geologic formations that could be tapped for well water in the Rock Creek valley include the following:

(1) Sedimentary formations comprising the bedrock in the lower part of the valley.

(2) Unconsolidated valley-fill deposits adjacent to the stream.

(3) Crystalline rocks comprising the bedrock in the upper part of the creek, in areas where the rocks are fractured or weathered.

The Leadville Limestone formation is perhaps the most significant aquifer in the sedimentary formations. Detailed geologic mapping is available showing where the formation outcrops in the McCoy area (Donner, 1949). Apparently there were tentative plans at one time for large-scale development of the ground-water resource; well yields in excess of 1,000 gpm were reported although concerns were also expressed about the quality of the water and the impact of pumping on surface-water flows (Boettcher, 1972). The Dakota Sandstone formation also outcrops at some locations in the lower part of the valley. The Dakota is a well known aquifer in Colorado, capable of yielding moderate quantities of ground water.

The valley-fill deposits along the course of Rock Creek should probably provide well yields of around 5 to 100 gpm, typical of sand and gravel deposits with only a thin saturated thickness. Subsurface investigations at dam sites A and B indicate that the valley floors at these locations consist generally of about 20 feet of sand and gravel overlying the bedrock surface (Morrison-Knudsen Engineers, 1986). There may be locations along

the course of the creek where the sand and gravel deposits could be thicker, resulting in greater well yields.

Well yields in the range of 1 to 5 gpm can be expected from wells completed in crystalline rocks, provided that secondary permeability is present due to fracturing or weathering. Granite is the most common type of crystalline rock present in the area, forming the core of the Gore Range (Tweto, 1976). Volcanic formations, including basalt, are also present in the lower reaches of the Rock Creek valley. Yields that could be expected from these formations are presently unknown. In other parts of the country, yields from highly fractured and jointed basalt can be quite high.

3.5.2. Muddy Creek. The Muddy Creek damsite is located in the Middle Park region of the BLM Kremmling Resource Area. The geology and ground-water hydrology of Middle Park is very complex. Unlike the eastern portion of Colorado, there are no large, well defined aquifers that yield large volumes of ground water. Most of the ground water is found either in alluvial aquifers, as might be found along the Colorado River, or in isolated pockets of porous sedimentary rocks. These latter sources are not considered aquifers because of their limited extent, great depth of burial, or probability of being drained.

Aquifers and ground-water sources are recharged primarily by infiltration from streams and percolation of precipitation. Middle Park has essentially a closed ground-water basin and very little ground water moves out of the basin. Ground-water quality and quantity is adequate for both domestic and lifestock use. It is infrequently used for irrigation.

Most of Middle Park is underlain with rock that is capable of yielding only small amounts of water. The alluvium is the principal source of ground water, yielding supplies adequate for domestic and livestock use. Most of the formations are nearly impermeable to water, which reduces the amount of ground water. In some areas, however, these formations are faulted and fractured so that some ground water is stored. Sedimentary rocks of the Tertiary system yield good water when the primary constituents of the formation are sandstone, sand, gravel, or boulders (USDI/BLM, 1984a).

3.6. Air Quality

3.6.1. Rock Creek. Air quality over Routt National Forest and the Rock Creek drainage is good with respect to all air pollutants. The largest source of air pollution from Forest activities is smoke from both wildfires and prescribed fires and dust from unpaved roads (USDA/FS, 1983).

The Forest Service role in air quality management is coordination of National Forest activities with State and Federal air quality control efforts. This is accomplished by properly managing the air pollution created by Forest Service activities such as prescribed fire, construction and use of roads, and the operation of various facilities. It also includes

review of ski area permit applications for potential air quality impacts from fireplace smoke and automobile exhaust. The Forest Service has a primary responsibility for protecting the Forest from adverse impacts created by external sources of air pollution, such as industrial plants and automobiles, by coordinating with the Environmental Protection Agency and the State of Colorado.

Fogs occur occasionally along State Highway 134 at Lynx Pass and around Long Park. The fog formation is the result of a combination of relative humidity, dew point temperature, and calm air.

3.6.2. Muddy Creek. The air quality over Muddy Creek is believed to be very good. There are no suspected pollutants in excess of Federal or State standards. The visibility within the area is also very good. The prevailing winds in the area are westerly, although local topography can affect surface wind patterns. The winds are generally strongest in the spring (USDI/BLM, 1984).

Another form of air movement common to the area is the air tide. Air tides occur on calm days and nights and are caused by the heating of the earth's surface. During the day the surface is warmed, causing a layer of air near the surface to warm and move upslope or upvalley as the warmed air rises. During the evening the flow reverses as the surface cools, causing the air layer to cool and flow downslope or down valley.

Valley inversions are caused by cold, dense air settling into these low-lying areas during the nighttime air tide movement. Inversions occur throughout the year but are most severe during the winter months. Kremmling, Granby, and Hot Sulphur Springs also have inversions regularly during the winter. No data have been collected on these local inversions, but the size of the valley and its shape affect the depth of the inversion. During the summer, the inversions disperse in the later morning, but during the winter they may remain for several days and possibly a week or more.

Fogs are common in Kremmling. Again, fog formation is a result of a combination of relative humidity and a dew point temperature. Fog persistence is attributed to the lack of winds, commonly found during temperature inversions.

Air quality monitoring data were generated by the Colorado Air Pollution Control Division in 1984 to provide a historical perspective on air quality. Air quality monitoring measures the concentrations of various pollutants (undesirable gases and particles) in the air. The monitoring is designed to address Federal and State requirements to determine pollutant concentrations related to both National Ambient Air Quality Standards (NAAQS) and pollutants for which standards may be anticipated. Primary standards are intended to protect public health. Secondary standards are intended to protect public welfare (Table 3.6.1). Pollutant concentrations that are higher than the standards are considered unhealthful, while concentrations below the standards are considered acceptable (CDOH, 1984).

Table 3.6.1
National Ambient Air Quality Standards and
Estimated Background Concentrations at Kremmling, Colorado

Pollutant	Averaging time	Concentration	Estimated background at Kremmling
Particulates (TSP)	Annual Geometric Mean:		
	Primary	75 ug/m^3	25 ug/m^3
	Secondary	60 ug/m^3 1/	
	24-Hours: 2/		
	Primary	260 ug/m^3	85 ug/m^3
	Secondary	150 ug/m^3	
Lead (Pb)	Calendar Quarter:		
	Primary	1.5 ug/m^3	0.05 ug/m^3
Carbon Monoxide (CO)	1-Hour: 2/		
	Primary	35 ppm	2.0 ppm
	8-Hour: 2/		
	Primary	9 ppm	2.0 ppm
Ozone (O_3)	1-Hour: 3/		
	Primary & Secondary	0.12 ppm	0.06 ppm
Nitrogen Dioxide (NO_2)	Annual Arithmetic Mean:		
	Primary & Secondary	0.053 ppm	0.015 ppm
Sulfur Dioxide (SO_2)	Annual Arithmetic Mean:		
	Primary	0.03 ppm	0.001 ppm
	24-Hour: 2/		
	Primary	0.14 ppm	0.08 ppm
	3-Hour: 2/		
	Secondary	0.5 ppm	0.05 ppm

1/ Federal guideline only.

2/ Not to be exceeded more than once per year.

3/ Statistically estimated number of days with exceedances is not to be more than 1.0 per year, averaged over a 3-year period.

ppm = Parts of pollutant per million parts of air.
ug/m^3 = Micrograms of pollutant per cubic meter of air at 760 mm Hg and 25°C.
mg/m^3 = Milligrams per cubic meter.

Note: Throughout this document, particulate pollutants are measured in ug/m^3 while gaseous pollutants are in ppm. However, some documents refer to gaseous pollutants in ug/m^3 (mg/m^3 for CO); therefore the standards for the gaseous pollutants are presented here in both units.

The Kremmling Resource Area is located within Air Quality Control Region (AQCR) Number 12 of the State of Colorado. According to Environmental Protection Agency (EPA) designations, the air quality of AQCR Number 12 is as follows:

TSP (Total Suspended Particulate): Better than national standards.

Sulfur dioxide: Better than national standards.

Oxidants (including ozone): Cannot be classified, or better than national standards.

Carbon monoxide: Cannot be classified, or better than national standards.
(Source: 40 CFR 81.306)

Air quality data for the area are limited. There are no existing air quality monitoring sites in the area; therefore the information in this section is based on generalizations and local observations (USDI/BLM, 1984a). Estimated background concentrations were obtained from CDOH (Table 3.6.1) (Chick, pers. comm., 1986).

The Clean Air Act Amendments of 1977 established a classification system to encourage the "prevention of significant deterioration" (PSD) of air quality in areas where the air is cleaner than national ambient standards. PSD Class I areas permit only minor increases in SO_2 and TSP levels above baseline amounts. Also, certain PSD Class I area managers have demonstrated visibility and other air quality related values to be important factors to be protected (USDI/BLM, 1984a).

PSD Class I areas east of the study area are of particular concern due to potential restrictions on development in order to meet the stringent air quality standards. Since the prevailing winds are from the west, development could be restricted by the regulatory authority to facilities that would not affect the air quality in these PSD Class I areas (particularly Rawah Wilderness and Rocky Mountain National Park) (USDI/BLM, 1984a).

3.6.2.1. Sources of Pollutants. Several sources of Total Suspended Particulates are located in the area. Teepee burners at sawmills in Walden, Kremmling, Granby, and Fraser, and open burning at a small sawmill in Kremmling are used to dispose of wood product wastes. This burning creates smoke and particulate matter in the local areas and, to some extent, downwind. Due to the current popularity of wood-burning stoves and fireplaces, additional smoke and particulates are produced in the towns during the winter months. During the fall and early winter the U. S. Forest Service and BLM burn slash piles and conduct broadcast burning of slash on timber sale areas in and around the resource area. This slash burning is conducted during good smoke dispersal conditions only (USDI/BLM, 1984a).

The amount of TSP emitted by the burning of wood in the area is not known. The effect the TSP has on the air quality of the area is also not

known but is not expected to be in excess of allowable standards except during some inversion periods. The smoke does create a visibility problem in the local areas during inversion periods.

Another source of pollutants is from the waferboard plant in Kremmling. The waferboard plant has recently come under scrutiny for air quality concerns, particularly for formaldehyde emissions. The Colorado Department of Health, Air Quality Control Division has identified this site for future monitoring of air quality.

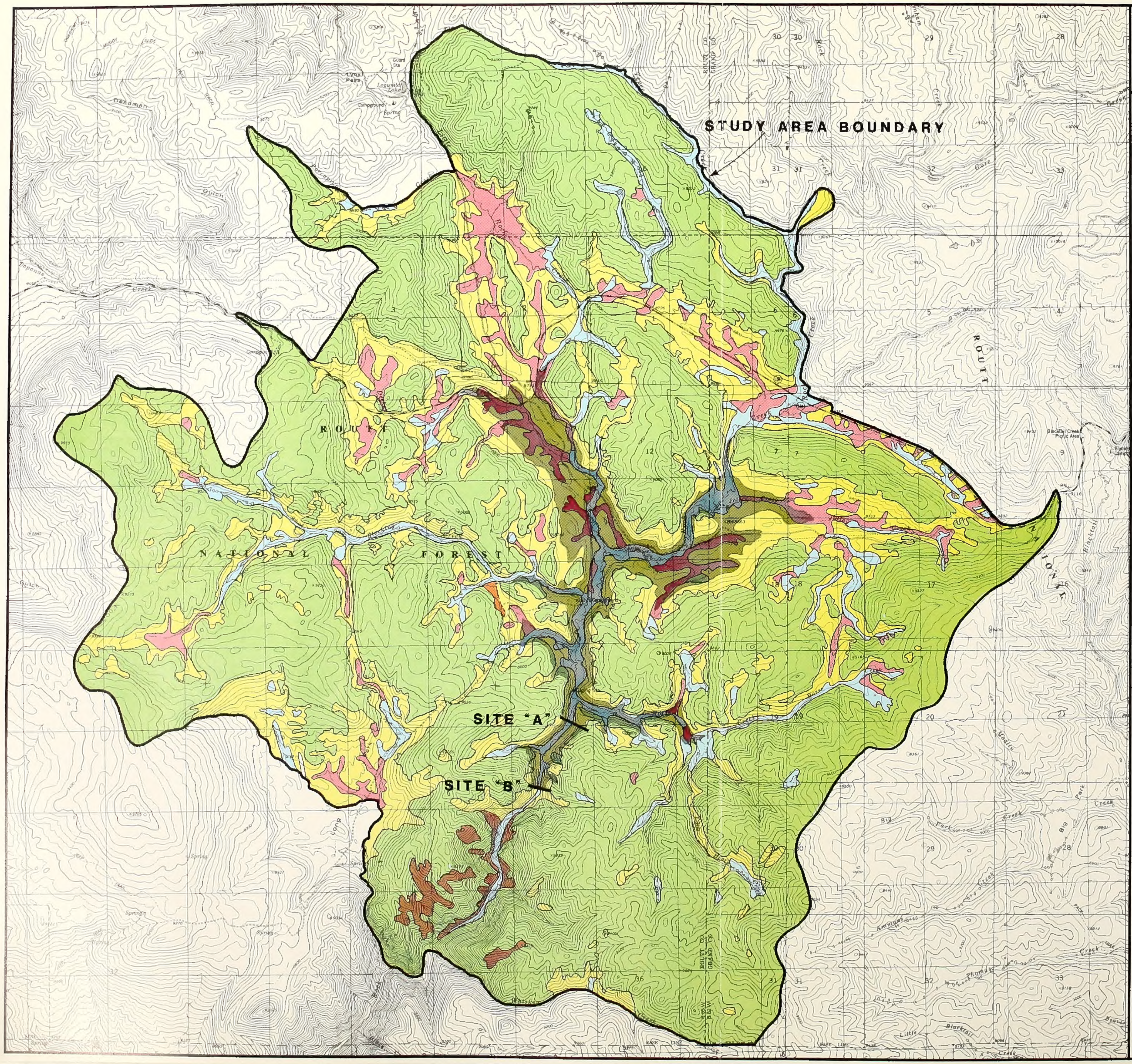
3.6.2.2. Inversions. The inversions that occur in the lower elevations of the Kremmling area can trap pollutants and particulates that could pose a possible health hazard. The inversions are most severe during the winter months. This is also the time when the most smoke and particulates are present from burning wood. The inversions trap the smoke and particulates as well as any other pollutants (such as exhaust emissions) that are present. The concentrations of pollutants are the highest when the inversion ceiling is lowest because there is a smaller volume of air to contain the pollutants. These inversions may limit the type of development within the area to those facilities that would not produce pollutants that would pose a health hazard during inversions (USDI/BLM, 1984a).

3.7. Vegetation

3.7.1. Rock Creek

3.7.1.1. General Vegetation. Information for this section was derived from on-site investigations of the study area and existing Forest Service data. For purposes of comparison between the Rock Creek and Muddy Creek sites, study areas with an equal reservoir to study area ratio were delineated. Vegetation of the Rock Creek study area is characteristic of the montane zone of the Middle Rocky Mountains. The predominant vegetation in the study area (19,265 acres) is coniferous forest surrounding non-forested openings. Four general vegetation community types occur within the area: forested, mountain brush, sagebrush association, and wetland types. Since wetlands are sensitive communities, they are discussed in greater detail in the following section (Section 3.7.1.2). Table 3.7.1 lists the community types, associated acreages and percents within the study area. Fig. 3.7.1 shows the distribution of these types within the study area.

The forested community type is the most prevalent in the study area. This type is characterized by an overstory dominated by lodgepole pine, but also including smaller amounts of subalpine fir, Engelmann spruce, and aspen. The structure and species composition varies with respect to microclimate, edaphic and topographic conditions, and the age or successional stage and management of a particular stand. Overstory canopy cover is highly variable ranging from near 100 percent in the stagnated "dog hair" lodgepole pine stands to 50 percent or less in the open stands approaching climax. Depending on the overstory canopy density, a sparse to



PROPOSED ROCK CREEK RESERVOIR

Figure 3.7.1

VEGETATION COVER TYPES

WETLANDS

- RIPARIAN WILLOW (Including Streams and Ponds)
- SUBIRRIGATED MEADOW (Including Streams and Ponds)

UPLANDS

- SAGEBRUSH ASSOCIATION
- MOUNTAIN BRUSH
- FOREST

N

SCALE

1 1/2 0 1 MILE

Table 3.7.1
Vegetation Community Types, Acreages, and
Percent of Total Area for the Rock Creek Study Area

Community type	Acreage	Percent of study area
Uplands		
Forested	13,464	70.0
Mountain brush	123	0.6
Sagebrush association	3,850	20.0
Total Uplands	17,437	90.6
Wetlands	1,828	9.4
TOTAL STUDY AREA	19,265	100.0

moderate (0 to 60 percent) understory shrub canopy layer often exists consisting primarily of common juniper, mountain lover, Oregon grape, wild rose, snowberry, bearberry, and grouse whortleberry. A forb and graminoid layer exists under the shrub and tree canopy, varying in density from 10 to nearly 100 percent depending on overstory canopy density. Species composition of this layer is highly variable; however, the following species are most prevalent in terms of cover and occurrence: elk sedge, pinegrass, fringed brome, heartleaf arnica, white-flowered peavine, wild strawberry, common lupine, sweet cicely, meadow-rue, fireweed, and bluebells. This community type is managed for several resource uses including timber, livestock range, wildlife habitat, and recreation opportunity (USDA/FS, 1986b).

The mountain brush type has a limited distribution within the study area. This type occurs primarily on the relatively steep, exposed dry slopes adjacent to and above the entrenched Rock Creek valley in the southern portion of the study area. A very sparse tree layer (less than 10 percent) may occur across this type consisting primarily of limber pine, Douglas fir, and aspen. A sparse to moderate (10 to 60 percent) shrub layer typically includes sagebrush, Gambel's oak, antelope bitterbrush, and snowberry. A large variety of forbs and graminoids comprise the ground cover and include: bluebunch wheatgrass, western wheatgrass, Indian ricegrass, fringed brome, mules ears, common lupine, wild buckwheat, pussy-toes, and bluebells. The mountain brush type is managed primarily for wildlife habitat, although some cattle grazing also takes place (USDA/FS, 1983).

The sagebrush association community type is located primarily along the margins of stream valleys adjacent to the forested type. This type is dominated primarily by a shrub cover consisting of a mosaic of mountain big

sagebrush and silver sagebrush. Mountain big sagebrush dominates on the upper, drier slopes with shallow soils and reduced available water. Silver sagebrush dominates on the lower slopes with gentle gradients, deeper soils, and greater water availability. Rabbitbrush and bush cinquefoil may occur in minor amounts. Generally, shrub cover varies from moderately sparse to moderate (20 to 60 percent). Forbs and graminoids occupying the inter-shrub areas provide additional cover. Total vegetal cover varies from moderate to dense (50 to 100 percent). The predominant graminoids and forbs include: sheep fescue, Idaho fescue, Thurber fescue, nodding brome, common lupine, Indian paintbrush, scarlet gilia, subalpine buckwheat, multiflowered phlox, and cinquefoil. The sagebrush association type is managed primarily as wildlife habitat but is also an important rangeland resource utilized by livestock (USDA/FS, 1983).

Wetlands occur in the bottomlands of the Rock Creek drainage surrounded by the sagebrush association type. Because wetlands are of special concern, they are discussed in detail in the following section.

3.7.1.2. Plant Species and Communities of Special Concern. No federally listed, candidate, or state designated rare species or communities are known to occur in the vicinity of the reservoir area or in the study area (O'Kane, 1986).

Wetlands are "lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface of the land or the land is covered by shallow water" (Cowardin et al., 1979). Wetlands are considered unique and of great value to wildlife. This value, in combination with a relatively limited distribution and areal cover, makes wetlands a special concern to the federal government and as such, are protected under the Clean Water Act.

Wetlands within the Rock Creek study area were identified following the Cowardin et al. (1979) classification system, using color aerial photographs (scale 1:18,000) and field survey. Four distinct wetland types were identified and include subirrigated meadow, willow/riparian, streams, and beaver ponds. Table 3.7.2 lists the acreages and percent of total areas of these types within the study area. Fig. 3.7.1 shows the distribution of these types within the study area.

The subirrigated meadow type (classification according to Cowardin et al., (1978): Palustrine Emergent Persistent Saturated, PlEMlB0t) is distributed along stream valleys between the sagebrush association type and the streams. This type is characterized by an intermittently to perennially wet or saturated soil or subsoil. Therefore, hydrophytic plant species predominate. The most common forb and graminoid species include: sedges, rushes, tufted hairgrass, inland bluegrass, wild strawberry, mountain blue violet, marsh marigold, bistort, cinquefoil, and buttercup. Shrubs consisting primarily of willow, silver sagebrush, and bushy cinquefoil may be sparsely distributed throughout this type with densities less than 10 percent. Typically, vegetal cover is very dense, varying between 90 and 100 percent. This vegetation type is managed for wildlife habitat and is also utilized by rangeland livestock for forage (USDA/FS, 1983). Range condition varies from fair to excellent but is predominantly good.

Table 3.7.2
Wetland Types, Acreages, and Percent of
Total Area for the Rock Creek Study Area

Community type	Acreage	Percent of total area
Wetlands		
Subirrigated meadow	856	4.0
Willow/riparian	883	5.0
Streams	24	0.1
Beaver ponds	65	0.3
Total Wetlands	1,828	9.4
Uplands	17,437	90.6
TOTAL STUDY AREA	19,265	100.0

The willow/riparian community type (Palustrine Scrub-shrub Deciduous Saturated, PlSS6B0t) occurs adjacent to both the subirrigated meadow type and the streams. This type consists of a shrub layer dominated by several species of willow, with minor amounts of dwarf birch and silver sagebrush. Shrub cover varies from 50 to 100 percent. Forb and graminoid species characteristic of this type are generally the same as described for the subirrigated meadow type. Total vegetal cover is very dense ranging from 95 to 100 percent. This type is managed for wildlife habitat and is also used for livestock grazing, with range conditions similar to the wet meadow type (USDA/FS, 1983).

Streams (Riverine Upper Perennial Unconsolidated Bottom, R3UB) cover a relatively small portion of the study area. This wetland type is characterized by relatively high flow gradients, dissolved oxygen content at or near saturation, fauna characteristic of running water (few or no planktonic forms), and a channel bed consisting of rock, cobble, gravel, or sand. Water temperatures are generally cold, providing habitat for a cold water fishery (see Aquatic Biology Section). Generally, stream banks are overgrown by willow or grasses and sedges.

A small portion of the area is composed of beaver ponds (Palustrine Unconsolidated Bottom, PlUB), which provide cold water fishery habitat as well as habitat for waterfowl and other wildlife species (See Wildlife Section 3.9.1).

3.7.2. Muddy Creek

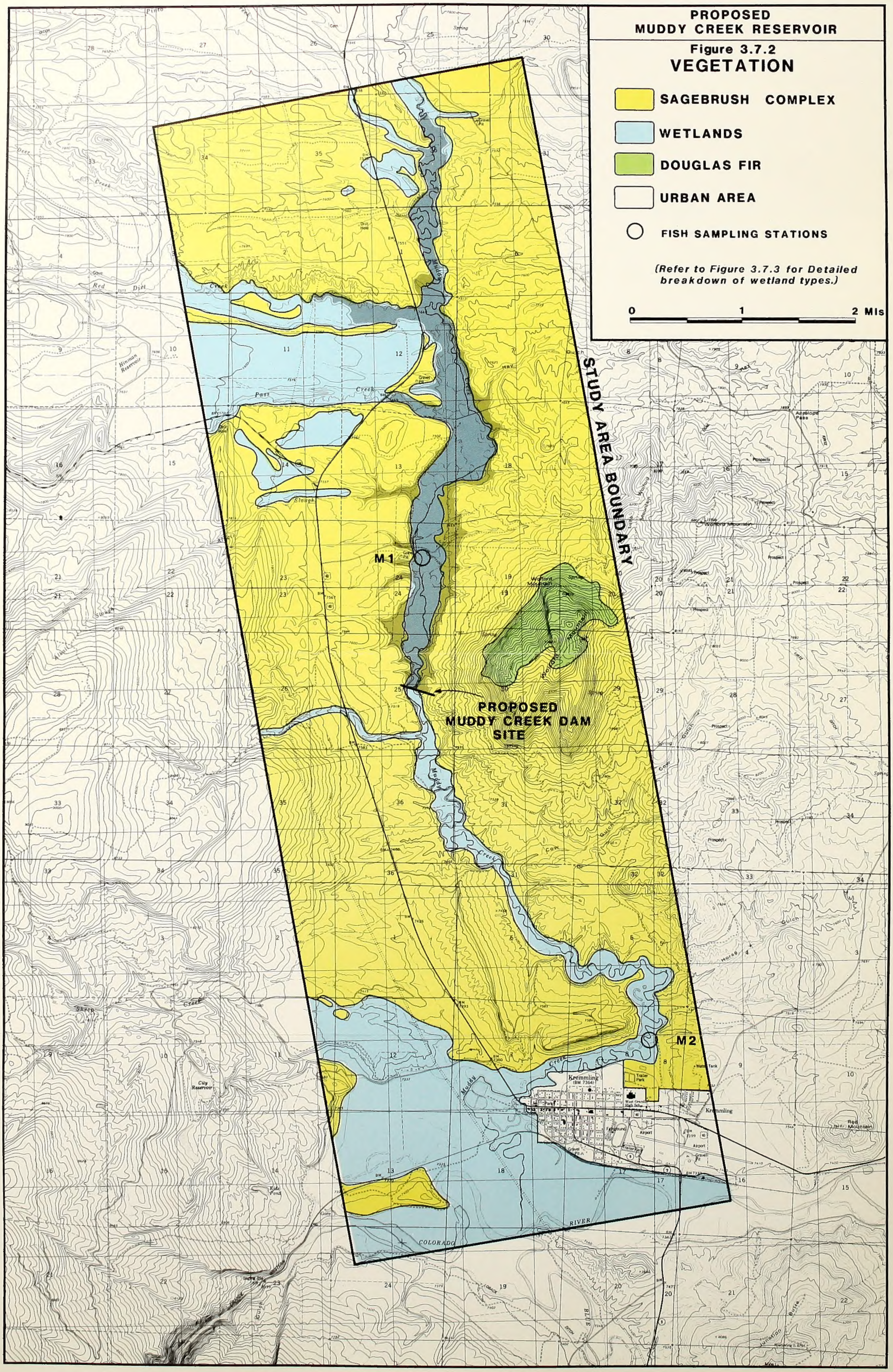
3.7.2.1. General Vegetation. The information for this section was derived from onsite investigations of the study area and comparisons with existing BLM data. For purposes of comparison between the Rock Creek and Muddy Creek sites, study areas with an equal reservoir to study area ratio were delineated.

Vegetation of the Muddy Creek study area (21,600 acres) is characteristic of the sagebrush steppe zone and portions of the montane zone of the middle Rocky Mountains. Vegetation in the study area is distributed according to the microclimate, edaphic, and topographic conditions of a particular location. Aspen and various species of conifers occur at higher elevations where temperatures are cooler, moisture more plentiful, and soils are deeper. At lower elevations where temperatures are higher, moisture is less plentiful, and soils are shallower or with some chemical characteristic not conducive to forest vegetation, shrubs and grasses are the predominant life-form. Numerous perennial and intermittent streams flow through the area. These streams are sources of perennial moisture where hydrophytic plants thrive, forming meadows and wetlands.

The predominant vegetation type of the study area is a sagebrush complex. Other vegetation community types identified within the study area include Douglas-fir open water wetlands, and wetlands which include hayland and pasture, willow and cottonwood riparian zones. Table 3.7.3 lists the acreages and percentages that these types cover in the study area. Fig. 3.7.2 shows the distribution of these types within the study area. These community types are surrounded at higher elevations by montane vegetation including lodgepole pine, aspen, mountain shrub, and grasslands; all are outside of the study area.

Table 3.7.3
Vegetation Community Types, Acreages, and Percent of Total Area for the Muddy Creek Study Area

Community type	Acreage	Percent of total area
Uplands		
Douglas-fir	408	2
Sagebrush complex	15,535	72
Urban (Kremmling)	616	3
Total Uplands	16,569	77
Wetlands	5,041	23
TOTAL STUDY AREA	21,600	100


PROPOSED
MUDDY CREEK RESERVOIR
Figure 3.7.2
VEGETATION
SAGEBRUSH COMPLEX
WETLANDS
DOUGLAS FIR
URBAN AREA
FISH SAMPLING STATIONS
(Refer to Figure 3.7.3 for Detailed breakdown of wetland types.)
0
1
2 Mls
STUDY AREA BOUNDARY
M1
M2
PROPOSED
MUDDY CREEK DAM
SITE
Kremmling
COLORADO
RIVER

The Douglas fir type generally occurs on steep exposed mountain slopes such as on Wolford and Little Wolford Mountains. This type is dominated by an overstory canopy of Douglas fir. Aspen may be a minor associated species. Overstory canopy cover ranges from 30 to 90 percent. Shrubs are a conspicuous component of this type with cover ranging from 20 to 60 percent. Shrub species may include: mountain maple, Oregon grape, mountain lover, wild rose, snowberry, and mountain ash. Forbs and graminoids may provide a dense ground cover ranging from 40 to 100 percent and include: heartleaf arnica, wild strawberry, aster, fireweed, sweet cicely, fringed brome, elk sedge, Wheeler bluegrass, and pinegrass. This type is managed by the BLM for timber, wildlife habitat, livestock grazing, and recreation (Harr, 1986).

The sagebrush complex type dominates the area at middle to lower elevations and is the most extensive community type in the study area. This type is primarily dominated by mountain big sagebrush. A large array of habitats and cover types are included in this community type and are distributed about the area in a mosaic fashion. On upland sites with relatively deep soils, associated shrub species include winter fat, snakeweed, antelope bitterbrush, and rabbitbrush. On drier exposed sites with shallow soils, associated species may include black sagebrush and fringed sage. On alluvial terraces and fans at the base of steep slopes within the Muddy Creek valley and tributaries, associated species may include basin big sagebrush, rabbitbrush, and greasewood. A large array of forb and graminoid species are associated with this type and include: bluebells, yarrow, Indian paintbrush, phlox, wild buckwheat, scarlet gilia, penstemon, milkvetch, bluebunch wheatgrass, western wheatgrass, bottlebrush squirreltail, and Indian ricegrass. Limited grass openings consisting of western wheatgrass, blue grama, purple three-awn, and galleta may be present within this community type. Areas with high clay or alkaline soils may contain alkali sagebrush, little rabbitbrush, Gardner saltbush, and matt-forming saltbush. On the steep sideslopes of the entrenched Muddy Creek valley, shrub species typical of the mountain brush type such as serviceberry and chokeberry may occur. Total vegetal cover may range from 20 to 80 percent. This type is managed primarily for rangeland grazing as well as wildlife habitat (Harr, 1986). The vast majority of the range resource provided by this type is in a fair condition category (USDI/BLM, 1984).

Wetlands, including irrigated haylands and pasture lands, are distributed in two different areas including the floodplains of Muddy Creek and its perennial and intermittent tributaries, and on the table lands above and adjacent to the incised Muddy Creek valley. Haylands and pasture lands on floodplains consist of a mozaic of areas that are naturally subirrigated and areas which are artificially flood irrigated. The grazing use and hay cropping has generally replaced much of the natural vegetation in areas that are naturally subirrigated. In some areas, overgrazing has greatly degraded the quality of this resource, while in other areas the vegetation has only been lightly utilized by livestock.

The hay and pasture lands on the relatively flat terraces above the Muddy Creek valley occur within the sagebrush complex type, which has been cleared of natural vegetation, leveled, planted with grass species, and flood irrigated. According to Volt (1986), these artificially flood irrigated areas have an average annual yield ranging from 1.0 ton per acre

to as high as 3 tons per acre (dry weight). In contrast, the hay and pasture lands on the Muddy Creek floodplain have average annual hay yields that range from only 0.75 to 1.0 ton per acre (dry weight).

The perennially wet nature of these areas provides the necessary conditions for the establishment and growth of hydrophytic plant species. Consequently, these areas are considered to be wetlands as defined by Cowardin et al., (1979).

Additional wetland areas include the open water and the willow and cottonwood riparian zones distributed about the subirrigated floodplains of the major perennial streams. These wetlands are discussed in the following section, since they are considered communities of special concern.

3.7.2.2. Plant Species and Communities of Special Concern. No federally listed plant species are known to occur in the vicinity of the reservoir site. However, five sensitive plant species, including two federal candidate and three state sensitive species and three plant associations of particular concern to the state of Colorado, are known to occur in the general vicinity of the reservoir site (USDI/BLM, 1984; O'Kane, 1986; Anderson, 1986). In addition, the Muddy Creek area contains numerous wetlands which are also of special concern due to their uniqueness and importance to wildlife.

Plant species of special concern that occur in the analysis area are listed in Table 3.7.4. Surveys for sensitive plant species were conducted during the summer of 1985 and 1986 within the reservoir inundation area and a one-half mile zone surrounding this area (Grah and Neese 1986). Osterhout's milkvetch and cyathophorus penstemon were found in the study area. The distribution of Osterhout's milkvetch is shown in Fig. 3.7.3. Pendland's penstemon was discovered in similar habitat in the adjacent Troublesome Creek drainage after the Muddy Creek survey was completed. This species was not observed to occur in the Muddy Creek study area during the survey. Three plant associations or communities of particular concern to the state of Colorado are known to occur in the study area. These associations are unique, relatively rare throughout their range, and are threatened by various land use activities. These include the Rocky Mountain juniper/bluebunch wheatgrass, Wyoming big sagebrush/bluebunch wheatgrass, and Wyoming big sagebrush/western wheatgrass associations. These associations are located to the north of Kremmling, Colorado, on the southern slopes of Wolford Mountain.

Wetlands were defined and their significance discussed in general in the Vegetation Section 3.7.1.2 of the Rock Creek alternative. The Muddy Creek project area supports a wide array of wetland types that cover approximately 5,041 acres, or 23 percent of the study area. The wetlands of the project area were identified, surveyed, and mapped following the Cowardin classification system using color aerial photos (scale 1:24,000) and on-the-ground field survey and type verification. Under the Cowardin system, nine distinct wetland types were resolved. Table 3.7.5 lists these types, their acreage, and percent cover in the study area. Fig. 3.7.3 shows the distribution of wetlands within the study area.

Table 3.7.4. Plant species of special concern that are known to occur in the general vicinity of the Muddy Creek reservoir site.

Common Name	Scientific Name	Status: Federal[a]	Status: State[b]	Habitat	Location
Osterhout's milkvetch	Astragalus osterhoutii	C2	G1S1	Grows on highly seleniferous soils (grayish-brown) derived from Niobrara shale on relatively flat areas, barren knolls, denuded clay hills, gulches, at the foot of gullied bluffs, and in wind eroded areas within the sagebrush complex community.	Numerous occurrences along Highway 40 on west side of Muddy Creek approximately 2 to 10 miles NNW of Kremmling, CO.
Harrington's penstemon	Penstemon harringtonii	C2	G1S1	Grows in open, on relatively flat, clay and silty clay loam soils which are often rocky, within the sagebrush complex community.	Closest occurrence is aproximately 9 miles south of Kremmling, CO., and 3 miles northwest of Green Mountain Reservoir.
Cyathophorus penstemon	Penstemon cyathophorus	—	GUSU	Grows in mountain brush and sagebrush complex community on hilly or mountainous upland sites.	Individuals were observed to be sparsely distributed throughout the Muddy Creek drainage area.
Neoparrya	Neoparrya megarrhiza	—	G3S1	Grows on barren dark gray to black shale slopes derived from a lower member of the Pierre Formation in the sagebrush complex community.	Closest known location is on a road cut approximately 3 miles south of Kremmling, CO.
Penland's penstemon	Penstemon penlandii	—	G1S1	Grows on strongly odoriferous selenium clay knolls derived from the Troublesome Formation within the sagebrush complex community.	Two known locations: Troublesome Creek drainage, approximately 8 miles northwest of Kremmling, CO; and Muddy Creek drainage, approximately 2 miles northeast of Kremmling, CO.

[a]Candidates for federal listing as threatened or endangered:
C2 - Threat and/or distribution data are insufficient to support federal listing.

[b]State ranked rare species:
G - Global ranking:
G1 - Critically imperiled globally; extreme rarity; few occurrences and vulnerable; critical national concern.
G3 - Very rare and local throughout range, or with very restricted range; threatened throughout range; 21-100 occurrences.
GU - Possibly in peril range-wide; but status uncertain; need more information.

S - State ranking:
S1 - Critically imperiled in Colorado because of extreme rarity; 1-5 known occurrences; critical state concern.
SU - Possibly in peril range-wide; but status uncertain; need more information.

Table 3.7.5
Wetland Types, Acreages, Percent of Total Area in the Muddy Creek Study Area

Community type	Acreage	Percent of total area
Wetlands		
Haylands and pasturelands		
Naturally subirrigated wet meadow	3,208	15
Artificially irrigated meadow	1,150	5
Willow riparian	442	2
Cottonwood riparian	23	0.1
Fast flowing streams	154	0.7
Slow moving streams	5	<0.1
Oxbows and ponds without vegetation	47	0.2
Oxbows with floating rooted vascular plants	11	<0.1
Oxbows with cattails	1	<0.1
Total wetland area	5,041	23.4
Total uplands	16,559	76.6
TOTAL STUDY AREA	21,600	100.0

The naturally subirrigated wet meadow type (Palustrine Emergent Persistent Saturated farmed and unfarmed, PlEMlBot), which dominates the flood plains of Muddy Creek and several major tributaries, is the most prevalent wetland type in the study area. This type occurs on the floodplains of Muddy Creek and its major perennial and intermittent streams in the area. Portions of this type are irrigated artificially by flooding. The transition between naturally subirrigated areas and artificially flood-irrigated areas is often very subtle and therefore difficult to distinguish. This community consists primarily of native hydrophytic species, but in some areas introduced species may dominate. Shrubs consisting of willow, birch, Wood's rose, and bushy cinquefoil may be sparsely scattered about this type. Graminoids include sedges, rushes, carpet bent, alkali cordgrass, meadow barley, and bluejoint reedgrass. Forb species include: checkermallo, Missouri iris, shooting star, bog orchid, blue-eyed grass, arrowgrass, and buttercup. This type is used primarily for pasture and wildlife habitat, and in some areas for hay cropping.

The artificially irrigated meadows (Palustrine Emergent Persistent temporarily flooded farmed, PlEMlOtf) comprise the second most common wetland type. This type occurs on the flat alluvial terraces with deep

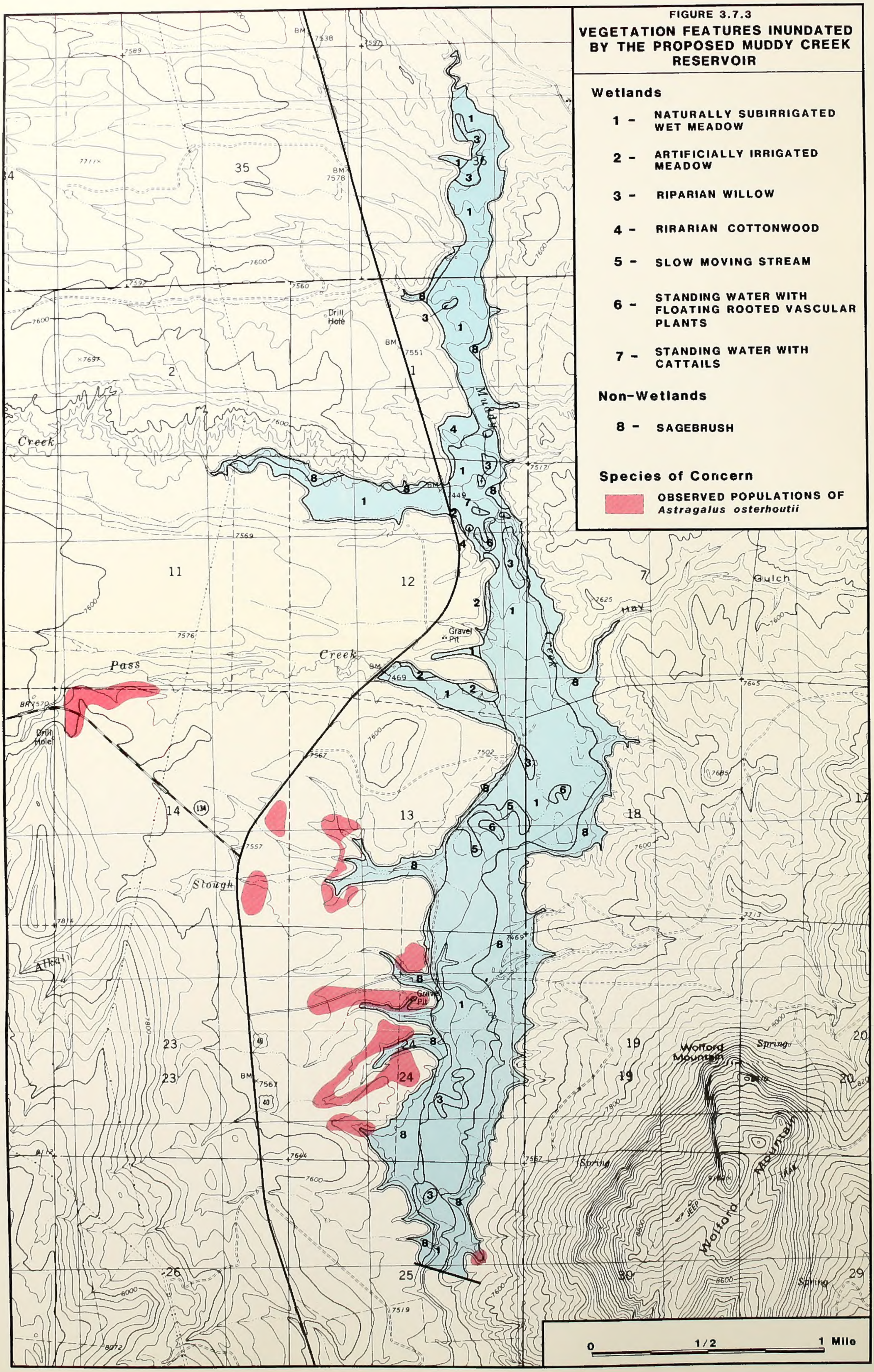


FIGURE 3.7.3
VEGETATION FEATURES INUNDATED BY THE PROPOSED MUDDY CREEK RESERVOIR
Wetlands
1 - NATURALLY SUBIRRIGATED WET MEADOW
2 - ARTIFICIALLY IRRIGATED MEADOW
3 - RIPARIAN WILLOW
4 - RIRARIAN COTTONWOOD
5 - SLOW MOVING STREAM
6 - STANDING WATER WITH FLOATING ROOTED VASCULAR PLANTS
7 - STANDING WATER WITH CATTAILS
Non-Wetlands
8 - SAGEBRUSH
Species of Concern
OBSERVED POPULATIONS OF *Astragalus osterhoutii*
0
1/2
1 Mile
Muddy Creek
Pass Creek
Hay Gulch
Slough
Wolford Mountain
Gravel Pit
Drill Hole
Spring

soils where the sagebrush complex has been cleared, seeded with grasses (primarily timothy and smooth brome), and flood irrigated. Generally, the frequency and duration of flooding have been sufficient for hydrophytic species such as sedges and rushes to establish. This type is primarily cropped for winter livestock feed but is also used for pasture. Vegetal cover is usually 100 percent.

Willow thickets (Palustrine Scrub-Shrub Deciduous Saturate, P1SS6B0t) and small stands of cottonwood (Palustrine Forested Deciduous Saturated, P1FO6B0t) are distributed about the floodplain of Muddy Creek and comprise the willow-cottonwood riparian type. Several species of willow dominate this type, and include primarily little sandbar willow and inland sandbar willow. Small isolated stands of narrow leaf cottonwood may occur within willow stands or separately. Other associated shrub to small tree-sized species include river birch, red osier dogwood, and narrow leaved alder. Forb and graminoid species listed previously for the subirrigated meadow type are also characteristic of this community. Total vegetal cover is typically 100 percent. These wetland types are used primarily by livestock and wildlife for forage and habitat (Harr, 1986). Heavy browsing of the shrubs and trees in this type is evident in many areas.

The perennial streams and rivers in the project area represent a wetland type (Riverine Upper Perennial Unconsolidated Bottom, R3UB). This type is characterized by water flow with a relatively high gradient, dissolved oxygen near saturation, no tidal influence, and fauna typical of running water (Cowardin et al., 1979).

Muddy Creek actively and continually wanders and varies its course within its floodplain in geologic time. Evidence of these changes include abandoned channels, cut-off meanders, and ox-bows. A large array of environmental conditions occur within these variations and thus, several different wetland types are represented. Abandoned channels with water characterized by low flow velocities, a low oxygen content, and faunal species typical of still water constitute a wetland type (Riverine Lower Perennial Unconsolidated Bottom, R2UB). Oxbows are distributed along the floodplains of the perennial streams of the project area.

The classification of the wetlands represented by oxbows is dependent on the depth of standing water, age of oxbow, and the stage of succession. Oxbows without vegetation (Palustrine Unconsolidated Bottom, P1UB) are considered a wetland type. The type also includes small stock ponds distributed throughout the study area.

Oxbows with vegetation are classified based on the life form of the dominant plants. These include: oxbows with floating rooted vascular plants such as pondweed, mares-tail, and water crowfoot (Palustrine Aquatic Bed Rooted Vascular, P1AB30t); and oxbows with cattails emerging out of the water (Palustrine Emergent Persistent Intermittently Exposed, P1EM1G0t).

3.8. Aquatic Biology

3.8.1. Rock Creek. Four permanent streams, Rock Creek, Little Rock Creek, Shoe and Stocking Creek, and Horse Creek may be directly affected either by inundation or altered flow regimes as a result of the proposed project. The major portion of the Rock Creek Basin within the area of concern is an open basin of fairly gentle gradient. The valley is much steeper in gradient both above and below the proposed reservoir basin. Most of the information in this section was derived from field studies in 1985 and 1986 (Holden and Hardy, 1986). Habitat measurements for Instream Flow Incremental Methodology (IFIM) analysis were made at five stations on Rock Creek, and one each on Little Rock Creek and Horse Creek. These stations were also sampled with multiple pass electrofishing to derive population/biomass estimates in October, 1985. Additional stations on Rock Creek and Little Rock Creek were sampled for fish numbers only.

Generally, the Rock Creek drainage area exhibits high quality cold water fisheries habitat. Rock Creek proper has excellent cover in the form of undercut banks, abundant pools and numerous beaver ponds. Substrate is generally a mix of cobbles, gravel and some fines. Streambanks are stable except where the stream cuts against the enclosing valley sides. The stream meanders through its valley at a rather leisurely pace and below the mouth of Little Rock Creek numerous old meanders maintain flow or are kept flooded by beaver ponds. Total stream miles on Rock Creek from the Highway 134 bridge to Dam Site B are about 5 miles, whereas this reach is only about 3 air miles in length. The USFS surveyed Rock Creek in the area of concern in 1983 and rated it as a very high quality fishery, primarily on the basis of frequent pools formed by beavers. Adequate water quality and flow for fish survival occurs year round in upper Rock Creek.

The IFIM analysis indicated that during base flow conditions of about 10-20 cfs brown trout adult Weighted Usable Area (WUA) was near 20 percent of the total available area of the stream for the three upper stations (R-1, 2 and 3) on Rock Creek. WUA is a measure of the amount of preferred or usable habitat in a section of stream. Station R-4, just above a steep canyon, had only about 2-3 percent of the total stream area as usable for adult brown trout. The 20 percent figure is very comparable to WUA for adult brown trout in the South Fork of the Rio Grande River and the Frying Pan River below Ruedi Reservoir, both considered to be excellent trout streams (Nehring, 1979). The Blue River in Summit County and Gore Creek in Eagle County, both Gold Medal Streams, had only 10-15 percent and 2-5 percent WUA for adult brown trout (respectively) during baseflow conditions (USDI/BR, 1985). Therefore, habitat quality and quantity at Rock Creek is excellent in relation to other recognized high quality trout streams in Colorado.

The proposed reservoir basin of Rock Creek occurs at elevations in excess of 8,000 feet and supports a biota typical of high Rocky Mountain streams. Abundance and biomass estimates of fish in this stream were made during fall 1985 at three stations (R-1, R-2, R-3) in the proposed reservoir basin (Fig. 3.10.1, Table 3.8.1). Reproducing populations of brown trout and brook trout and stocked rainbow trout were the game species found

Table 3.8.1 Fish abundance and biomass per acre in selected areas in Rock Creek and tributaries.

Site	Brown Trout #s/ac	Brown Trout lbs/ac	Brook Trout #s/ac	Brook Trout lbs/ac	Rainbow Trout #s/ac	Rainbow Trout lbs/ac	Total Trout #s/ac	Total Trout lbs/ac	Non game species #s/ac	Non game species lbs/ac
Rock Creek										
1/4 mile above hwy [1]	75.0	----	56.2	----	12.5	----	218.7	----	81.2	----
IFIM Sta R-1	360.0	69.4	40.0	4.5	80.0	31.4	480.0	105.3	19.0	22.7
R-2	170.0	46.9	130.0	5.9	20.0	5.8	320.0	58.6	10.0	11.0
R-3	141.7	30.0	16.7	.1	00.0	----	158.4	30.1	75.0	2.0
R-4	175.0	47.6	00.0	----	50.0	26.5	225.0	74.1	00.0	----
R-5	45.2	36.0	00.0	----	00.0	----	45.2	36.0	<150.0[2]	2.0[2]
Little Rock Creek										
@ hwy [1]	2340.0	----	3325.0	----	800.0	----	6465.0	----	00.0	----
IFIM Sta LR-1	375.0	10.9	2562.5	175.0	00.0	----	2937.5	185.9	00.0	----
Shoe & Stocking Creek										
1/2 mile up stream[1] from confluence with Rock Creek	00.0	----	8800.0	----	00.0	----	8800.0	----	00.0	----
Horse Creek										
IFIM Sta H-1	40.0	----	1500.0	----	00.0	----	1540.0	----	00.0	----

[1]Conservative estimate based on 1 electrofishing pass, fish not weighed
[2]Estimated, numerous sculpins not captured.

in the area. Brown trout was the dominant species in all three stations, and increased in dominance in downstream stations (Table 3.8.1). Rainbow trout occurred in most of the stream sections as a result of stocking activities but were the least abundant species of trout. Approximately 4500 catchable rainbows have been stocked in the Rock Creek system annually during the last few years. Total trout biomass in these three stations ranged from 30.1 lbs. per acre in Rock Creek near the proposed dam site (Station R-3) to 105.3 lbs per acre at the upper station (R-1).

Nongame species present in the Rock Creek drainage were limited to longnose sucker. Biomass of suckers was relatively low, ranging between 0 and 17 percent of the total fish biomass (Table 3.8.1).

Above the proposed reservoir basin, Rock Creek is considerably straighter and has a faster current due to the steeper gradient. Habitat is still excellent, but undercut banks and beaver ponds are not nearly as common as in the proposed reservoir basin. Stream banks are generally stable and substrate includes boulders as well as gravel and cobbles. Fish sampling in this area (Station R-6) showed good numbers of brown and brook trout and a few rainbows. Weight was not measured so biomass could not be determined.

Below the proposed reservoir basin, the stream drops rapidly into a steep canyon. Velocities are high, substrate is primarily boulders and bedrock, small waterfalls and plunge pools are frequent, and banks are lined with alder. This canyon runs for about 3-4 miles and then gradually the stream gradient and velocity decreases and the stream becomes a long series of fast runs interspersed occasionally with short riffles or falls. Cover is afforded by the overhanging vegetation but undercut banks and pools are not very common. The stream gradually becomes less steep as it approaches McCoy, undercut banks become more common and overall fish habitat quality improves. Fish were sampled at a station near the head of the canyon (Station R-4) and also near McCoy (Station R-5)(Table 3.8.1). Primarily brown trout and rainbow trout adults were found at Station R-4 (Table 3.8.1), with very few juveniles. Only brown trout were found at Station R-5 near McCoy and again only adult fish. The fish at Station R-5 may have been spawners from the Colorado River since their average weight was greater than other areas of Rock Creek. The only additional fish species found in this lower section of Rock Creek was the mottled sculpin which was abundant at McCoy but comprised less than five percent of the total biomass.

Little Rock Creek (Fig. 3.10.1) is considerably smaller than Rock Creek, averaging 5-10 feet in width. Habitat quality is generally excellent with undercut banks and abundant pools. Substrate is gravel/cobble with considerable silt and sand in the lower 1/4 mile above its mouth. Streambanks are generally very stable with low willows and grasses the major riparian vegetation. Fish sampling at Station LR-1 produced high numbers of young and juvenile brook trout and some juvenile brown trout. Biomass was calculated at 185.9 pounds per acre, greater than any of the main Rock Creek Stations. Qualitative sampling at Station LR-2 near Highway 134 produced large numbers of adult and juvenile brook and brown trout and a few rainbows. Rainbows are stocked into this portion of the

stream. Although biomass was not measured, using the numbers collected (Table 3.8.1) and the length-weight relationship of fish from other Rock Creek stations, biomass may have approached 500 pounds per acre, the highest of any station sampled in the area.

Shoe and Stocking Creek enters Rock Creek near the existing camping area. This small stream is hardly visible due to a heavy growth of willow that hides the 2-3-foot wide channel. Substrate is cobble/boulder in the lower section but the stream gradient decreases further up the stream and finer substrates become more common. Beaver ponds are also found in the upper sections of this stream, about 1/4 mile above its mouth. Habitat is excellent with undercut banks and pools common. Qualitative sampling in the stream found only brook trout, primarily young and juveniles, but very high densities (8800/acre).

Horse Creek enters Rock Creek near alternate Dam Site A. It is similar to Shoe and Stocking Creek in size and general form, except that beaver ponds covered most of the portion of concern, including the IFIM station. Habitat quality is excellent which is reflected in a fairly dense population of brook trout and a few brown trout (Table 3.8.1).

3.8.2. Muddy Creek. Most of the information in this section was derived from field work conducted in the area of concern (Holden and Hardy 1986). Two IFIM stations were placed on Muddy Creek. Station M-1 was located within the proposed reservoir basin, and Station M-2 was located just above the town of Kremmling (Fig. 3.7.2). Fish sampling was conducted at both stations in October, 1985.

Elevation of Muddy Creek in the vicinity of the proposed dam is approximately 7000 feet, sufficiently high for a cold water stream to occur. However, the stream exhibits relatively high turbidities and overall poor trout habitat due to bank erosion and siltation in the vicinity of the proposed reservoir. Relatively little cover is available within the stream, with undercut banks almost nonexistant and overhead cover minimal. Pools occur, but are often heavily silted. Substrates range from cobbles, heavily imbedded in fines, to sand and silt in slower sections. Sampling during fall 1985 indicated that no game fish populations were present in Muddy Creek at either of the aquatic stations. Fish populations were predominately composed of bluehead sucker, white sucker, mottled sculpin and speckled dace. Roundtail chub and creek chub also occurred in Muddy Creek but were not common.

Upper Muddy Creek, well above the proposed reservoir basin, supports stocked rainbow trout and a northern pike was caught in lower Muddy Creek.

3.8.3. Other Areas

3.8.3.1. Blue River (below Green Mountain Reservoir). The Blue River below Green Mountain Reservoir is an excellent reach of cold water habitat. The area has a good combination of riffles, runs and pools with cobble-boulder substrates. The upper 2-3 miles just below the dam is entrenched in a

steep canyon. The lower sections down to its confluence with the Colorado River are more open, meandering through grazing and rural agricultural areas.

The Blue River below Green Mountain Reservoir is classified by the CDOW as a Gold Medal Water because of the excellent brown and rainbow trout fishery. Gold Medal waters are the highest quality aquatic habitat for trout that exist in Colorado and offer the greatest potential for trophy trout fishing and angling success. The first 2.5 miles below Green Mountain Reservoir are classified by the CDOW as a Wild Trout Water due to the spawning of brown trout in the area. Wild Trout Waters support a naturally reproducing and self-sustaining trout population without stocking (CDOW 1985). Rainbow trout are stocked annually in this reach of river (Burkhard and Smith 1980).

3.8.3.2. Main Stem Colorado River. The Colorado River from the Kremmling area downstream to the Colorado-Utah line is the area of concern. This length of river encompasses a variety of river habitats. However, it can be divided into two major sections, a cool water portion dominated by trout and other cold water fishes and a warm water portion dominated by warm water fishes.

The cool water section extends downstream to near Rifle, Colorado, a distance of approximately 75 miles. This section generally exhibits cobble-boulder substrates, a diversity of riffles, runs and pools and a stable vegetated shoreline. The primary game species are rainbow and brown trout. Rainbow trout, and occasionally cutthroat trout, are stocked annually. Brown trout reproduce naturally in this section, utilizing the mainstem river as well as tributaries for spawning. CDOW has classified the reach from upper Gore Canyon to State Bridge as a Wild Trout Water.

The warm water portion extends downstream from Rifle and is a cobble-bottomed stream with swift flows. Non-game fishes dominate this section of the river. Most common species include the flannelmouth sucker, bluehead sucker, roundtail chub, red shiner and common carp. The primary concern in the area below Rifle is the presence of several endangered fishes, which are discussed in the following section.

3.8.4. Threatened and Endangered Fishes. No federally threatened or endangered fish are known to occur in Rock Creek and its tributaries, Muddy Creek, the Blue River, or the mainstem Colorado River above Rifle.

Three fish species listed as endangered are found in the Colorado River below Rifle. They include, the Colorado squawfish, humpback chub and bonytail chub. One candidate species, the razorback sucker, is protected by the State of Colorado is also found in the Colorado River below Rifle. The Colorado squawfish probably inhabited the Colorado River up to Rifle in the past. Presently, it is restricted to the section below Highline Dam near Palisade, Colorado which is an effective barrier to upstream migration.

The Colorado squawfish is generally uncommon to rare throughout the mainstem Colorado River from Lake Powell to Highline Dam but can be locally common in certain habitats at certain times of the year (Valdez et al., 1982). Adults utilize a variety of habitats, including bankside runs year-round and large backwaters during runoff (Holden and Wick, 1982). Juveniles and young of the year prefer backwaters. Spawning apparently occurs in several areas near and below the mouth of the Gunnison River. Time of spawning is July or early August when river temperature is about 70 degrees F. Clean cobble bars are the preferred substrate in the Green River system (Archer et al., 1984) and similar areas are probably used in the Colorado River.

The humpback chub has been found in several locations in the Colorado River but appears to be most abundant in three canyon habitats below the mouth of the Gunnison River. These are Black Rocks near the Gunnison River; West-water Canyon, located between Grand Junction, Co. and Moab, Ut.; and Cataract Canyon located between Moab and Lake Powell. Each of these areas is characterized by very deep (up to 70 feet) holes and turbulent, fast water velocities during high water. Adult humpback chubs prefer deep, swift runs and eddies with boulder or rocky substrates (Valdez and Clemmer, 1982). Young fish prefer backwaters and other quiet water areas near shore in the same canyons. Spawning apparently occurs in or near the deep canyon habitats preferred by the adults during late May or June at a water temperature of approximately 60 degrees F.

The bonytail chub is practically extinct in the Upper Colorado River Basin. No specimens had been collected from this area since the early 1900's until 1984 when one adult was collected in Black Rocks (Lynn Kaeding, USFWS, pers. comm.). Very little is known about the ecology of the bonytail chub.

The razorback sucker was once fairly common in the Colorado River as far upstream as Rifle (Clee Sealing, CDOW, pers. comm.). Fairly large concentrations of adult fish still occur in backwaters in the Grand Junction area during spring runoff but otherwise are uncommon. Very few young razorbacks have been collected or observed, consequently little is known about their habitat preferences. Spawning apparently occurs in May at river temperatures of 55-60 degrees F over cobble-gravel bars. However, ripe adults have also been taken in slow water habitats (Wick et al. 1982).

3.9. Wildlife

3.9.1. Rock Creek

3.9.1.1. General Wildlife. The study area for wildlife resources was selected by the USFS (Fig. 3.7.1) to include Rock Creek and its tributaries in the general proposed reservoir area. The relative size of the study areas for Muddy Creek and Rock Creek are similarly proportioned to their reservoir sizes in order to accommodate direct comparisons.

Habitat in the proposed reservoir site is composed of sagebrush association, subirrigated meadows, and willow riparian habitats. The site is surrounded by forested habitats comprised mainly of lodgepole pine. Detailed descriptions of the habitats, cover types, and acreages of each in the study area can be found in the Vegetation Section and Table 3.7.1.

Indicator species, species selected to represent a group of species or guild that utilize certain habitats in the same way, are used by the USFS to describe the wildlife and/or wildlife habitats of a given area. The USFS indicator species for the study area are: mule deer, Rocky Mountain elk, moose, beaver, pine marten, mallard, blue grouse, goshawk, green-tailed towhee, warbling vireo, Wilson's warbler, hairy woodpecker and three-toed woodpecker (Reed, 1986). Due to the high elevation of the area (about 8600 feet), winter use by the indicator species is generally limited to blue grouse, goshawk, pine marten, and the two woodpeckers. More detailed descriptions of the habitat used by these indicator species can be found in the Forest Plan (USDA/FS, 1983).

Elk are present on the study area mainly during months when snow does not restrict their mobility, late-April or early-May through November or mid-December. Use of the study area by elk is prolonged in years of unusually light snowfall and shorted during years with early winters or late springs. Several elk migration corridors go through and near the study area. The corridors are used mainly during fall movements from summer ranges to winter ranges at lower elevations. Most of the big game migration occurs in the Blacktail and Toponas Creek drainages (Schnurr, 1985; Chanson, 1985). Portions of the study area are also probably used for elk calving.

Numbers of elk actually using the study area vary greatly by season with peak densities likely during the fall migration. Elk using the study area are part of Big Game Management Unit 15, which is part of the CDOW Data Analysis Unit E-7 (Gore Pass Unit). Elk hunting provides a major recreation opportunity in and around the study area. In 1983, the southern portion of Unit 15 (15S) had a total harvest of 88 elk (CDOW, 1984a), a portion of which ocurred within the study area.

Mule deer also utilize the area as summer range, though for a shorter period (late-May through November) than elk because they are less able to move through deep snows prevalent in this general area. Deer migration corridors are similar to those described for elk. Some fawning likely occurs within the study area. Deer also provide a major recreation opportunity in and around the study area. Deer using the study area are part of Big Game Management Unit 15 which is part of Data Analysis Unit D-8 (State Bridge Unit). Total harvest for Big Game Unit 15 for 1983 was 862 deer (CDOW, 1984a). A portion of this harvest occurred within the study area. Generally, spring and summer range is considered less critical or limiting for big game species than winter range. Characteristics of adequate summer range include abundant food, cover (especially concealment for rearing of young), water and limited human disturbance. Summer range is important because it supplies the quantities and quality of food necessary to provide energy for growth and development needed for reproduction and fat deposition. Summer range is usually not a conspicuous limiting factor, but a

lack of quality summer range can lead to nutritional problems which may eventually manifest themselves in the form of winter mortality and decreased productivity. Portions of the Rock Creek study area are good to excellent summer range for deer and elk, especially the areas along and near the streams.

Human disturbance on big game is often translated into road density because access by vehicle is directly related to the amount of visitation an area will receive. Roads through the study area include 5.73 miles of paved all-weather road (Colorado Highway 134), 8.15 miles of graveled 3 season road, 4.27 miles of 4-wheel drive or dry season road, and 3.88 miles of ATV trails. The overall road density of the study area is 0.653 miles of road per square mile, which indicates a low level of human presence. Fishermen and campers provide considerable disturbance on weekends in portions of the area but the level of this disturbance is lower during the week.

Therefore, the Rock Creek study area provides some very good deer and elk summer range, but the use of the area by these species is probably slightly below its potential because of the available human access and disturbance.

Other big game species potentially occurring in the area include black bear and moose. Black bears are present in low densities within the study area. Moose were released in the Routt National Forest and have been sighted in the study area. The study area provides potential habitat for moose if numbers should increase.

Avian game species within the study area are limited to several species of dabbling ducks, Wilson's snipe, and blue grouse. Small numbers of these species nest within the study area and provide hunting opportunities in the fall. During the fall migration, several additional species of ducks stopover along the creek. Numbers of waterfowl are generally in the lower ranges for density. The study area is within Small Game Management Unit 28 which has one of the highest success rates for blue grouse hunting in Colorado (CDOW, 1984b).

In addition to the game species mentioned, the Rock Creek study area hosts several terrestrial and aquatic furbearers. Most notable among these are bobcat, beaver and coyote. Beavers are abundant and probably number in excess of three beaver per stream mile. Numerous old and new dams were found along Rock Creek, Horse Creek and Shoe and Stocking Creek in 1986 (Pekins and Hugie, 1986). Coyotes likely exist in moderate densities within the study area.

The Rock Creek study area provides habitat for numerous species of non-game birds and small mammals. In spring 1986, 16 species of passerines and representatives from an additional four avian orders were observed. Limited habitat exists for avian species using cliff, canyon walls and aspen habitats. Small mammals using the study area include a variety of rodents, chipmunks, ground squirrels, and tree squirrels. Many of the non-game birds and small mammals provide a food base for terrestrial and avian predators.

Common raptors found in the study area include the red-tailed hawk, goshawk, American kestrel, and great horned owl. No nests were located but breeding pairs for all three species have been observed in the area (Kung, 1986). Nest sites vary somewhat by species but generally include microhabitat within the lodgepole forests surrounding the open meadows. Osprey and golden eagles visit the area but are not common. Additional species of raptors likely pass through the study area during migration but do not nest there.

3.9.1.2. Threatened and Endangered Species. Species listed by the USFWS as federally threatened or endangered that are known to occur within Routt National Forest include the bald eagle, peregrine falcon and whooping crane. None of these species are known to nest within the study area (USFWS, 1986) and are considered infrequent users during snow-free months. No recent records were found noting their occurrence within or near the study area. Bald eagles are generally associated with water because they forage heavily on fish. Although no bald eagles were seen during recent raptor studies (Kung, 1986) potential feeding habitat does exist within the study area.

Species listed by the CDOW as endangered that are known to occur within Routt National Forest include the greater sandhill crane, wolverine and lynx. The greater sandhill crane is a potential summer visitor to the Rock Creek area, but the area is at the upper limits of potential crane habitat. No recent observations of wolverine or lynx have been recorded in the study area.

3.9.2. Muddy Creek

3.9.2.1. General. The study area for wildlife resources was defined as the area proposed for flooding and important wildlife habitat near the reservoir basin that could be affected (Fig. 3.7.2). The Muddy Creek site has the same reservoir to study area ratio as the Rock Creek site.

The general habitat in the Muddy Creek area consists of sagebrush communities at higher elevations with naturally and artificially irrigated meadows and riparian communities along the stream and its tributaries. A Douglas fir community is found on Little Wolford and Wolford mountains. Approximate acreages of habitat types within the study area are listed in Tables 3.7.3 and 3.7.5. A more detailed description of the habitats and cover types can be found in the Vegetation Section.

Important big game species within the area of concern include pronghorn antelope, mule deer, and Rocky Mountain elk. All three species winter in or near the study area. During summer months, very few elk and deer and an occasional antelope are found within the study area, primarily on Wolford Mountain. Deer and elk utilize summer range at higher elevations in the surrounding area.

The small herd of about 10 pronghorn antelope wintering in the study area (USDI/BLM, 1984) belong to the Pronghorn Antelope Troublesome Unit by the CDOW. This unit occupies an 8.4 sq. mile area approximately 3.5 miles east of the proposed Muddy Creek dam site during portions of January through April. CDOW personnel (Shnurr, 1985) believe that the herd is expanding and predict an expansion of their range in the future.

Part of the Middle Park mule deer herd inhabits the study area. Data for this portion is grouped into Data Analysis Unit D-9 (DAU D-9) by the CDOW. This herd has been extensively studied by the CDOW (Gill et al., 1969; 1970; 1971; and Carpenter et al., 1979). DAU D-9 is comprised of 426 square miles of winter range (Schnurr, 1985), of which 24 sq. miles are severe winter range and 89 square miles are winter concentration areas. These range classifications are defined as follows (Okon, 1987):

<u>Winter range</u>: That part of the home range of a species where 90% of the individuals are located during a specific period of winter during the average five winters out of ten.

<u>Severe winter range</u>: That part of the range of a species where 90% of the individuals are located when the annual snowpack is at its maximum in the two worst winters out of ten.

<u>Winter concentration areas</u>: That part of the winter range of a species where densities are 100% greater than the surrounding winter range density during the same period used to define winter range in the average five winters out of ten.

Middle Park contains four distinct mule deer subunits based on a herd's fidelity to a wintering area (Carpenter et al., 1979). The study area contains the Muddy Creek subunit (Game Management Units 181 & 27). Mule deer in this subunit migrate from summer range at higher elevations to winter range at lower elevations near the town of Kremmling. The population of the Muddy Creek subunit has varied substantially during 1968-1984 when aerial surveys were conducted to estimate animal numbers (Fig. 3.9.1).

Elk inhabiting the area are part of DAU E-7 and E-8 incorporating Game Management Units (GMU) 27 and 181. Combined, the DAUs contain 513 square miles of winter range, of which 149 square miles are severe winter range and 105 square miles are winter concentration areas, as well as 43 square miles of known production areas (used for calving and fawning). Winter range is considered critical habitat by the CDOW. No specific production areas are delineated in DAU E-8, but production areas tend to follow the snowline in transitional habitat between summer and winter range. Generally, mule deer and elk occupy winter range from December to May (Schnurr, 1985), with specific timing dependent on weather conditions.

The elk population for Middle Park (comprised of portions of several elk DAUs) is estimated to be 5,000 (±20%) animals (USDI/BLM, 1984). The populations of mule deer and elk in DAU D-9, E-7, and E-8, have a high buck to doe ratio partly due to a lower than average harvest of the herds (Schnurr, 1985). A winter survey of big game conducted within the study area during January 1986 enumerated approximately 480 elk and 700 mule deer using portions of the study area. This count must be considered the minimum number of game using the area during the winter of 1986.

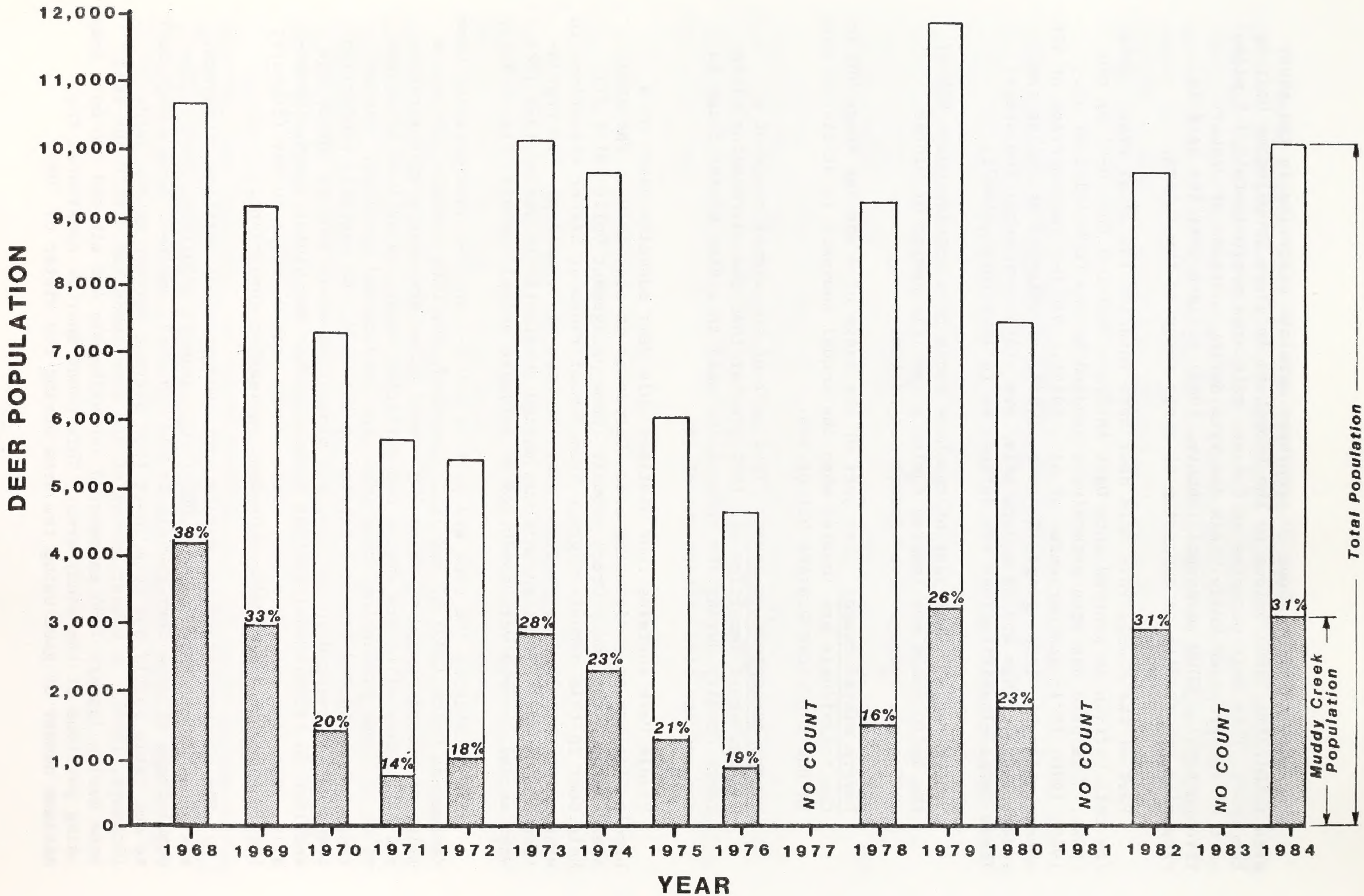


FIGURE 3.9.1. Fluctuations in Middle Park deer population from 1968-1984 as estimated from aerial surveys. (Muddy Creek subunit is shown in grey.)

Use of the study area by these species is affected by several factors including: forage availability, snow conditions, and solar radiation. Forage availability is influenced by range condition and snow conditions. Range condition varies considerably within the Muddy Creek area, with many areas being in only fair condition. Much of the area along the stream appears to suffer from past overgrazing. Snow conditions are based on depth, density, and duration of snow cover. The greater the snow cover, and/or the longer it lasts, the less area is accessible for deer or elk. The areas of higher elevation tend to have deeper winter snowpack, forcing the animals, especially deer, down the basin and closer to Kremmling. Thermal benefits from solar radiation are influenced by slope and aspect. Solar radiation reduces snowpack in areas that would otherwise be inaccessible. Elk and mule deer often occupy separate wintering areas within the study area because of differences in foraging behavior, interspecific dominance and mobility in snow (Spowart, 1986). The actual portion of the winter range used by both species changes throughout the winter depending on snow conditions (Gilbert et al., 1970), with a down-basin movement of animals occurring as the snowpack deepens.

Important winter forage for mule deer includes serviceberry, bitterbrush, snowberry, sagebrush, bluebunch wheatgrass, and forbs (Carpenter, 1976). While deer are generally considered browsers, Gill et al. (1975) found bluebunch wheatgrass to be the most utilized species in mid-winter. Other graminoids and forbs are also important components of the winter diet. Typical winter elk foods include Kentucky bluegrass, timothy, bluejoint reedgrass, sedges, willows, shrubby cinquefoil, needle and thread, and bitterbrush (Hobbs et al., 1981). However, forage use by both species is a function of forage availability, therefore, food habits vary from area to area, depending of vegetative cover above the snowpack. In severe winters, these species also utilize forage fed to domestic animals and in extreme cases, winter conditions have warranted artificial feeding of these animals by CDOW.

A critical period for wintering big game is generally late winter-early spring when fat reserves are at their lowest and energy requirements are increasing in conjunction with a rise in basal metabolic rate after an obligatory decrease in the winter (Milchunas et al., 1978). Early winter snows are also harmful as obligatory fat deposition occurs in the fall and loss of available forage by snow cover may influence the amount of fat deposited (Milchuras et al., 1978). A combination of early heavy snow and low temperatures produces the worst scenario for winter survival of big game, mainly mule deer (Carpenter et al., 1984). Cold temperatures alone are not the primary factor in determining winter survivability. Other climatic factors such as wind and solar radiation as well as availability of forage and amount of stored fat interact with temperature and snow depth to produce an overall effect on individuals. Selection of microhabitat such as western or southern exposures or areas out of the wind can temper climatic conditions and reduce physiological stress.

Snow and temperature conditions vary from year to year, with extreme conditions having serious impacts on the deer and elk herds. The CDOW maintains two snow study areas located about 3.5 miles southwest of Kremmling in Copper Gulch and along Elliot Creek which exhibit similar weather

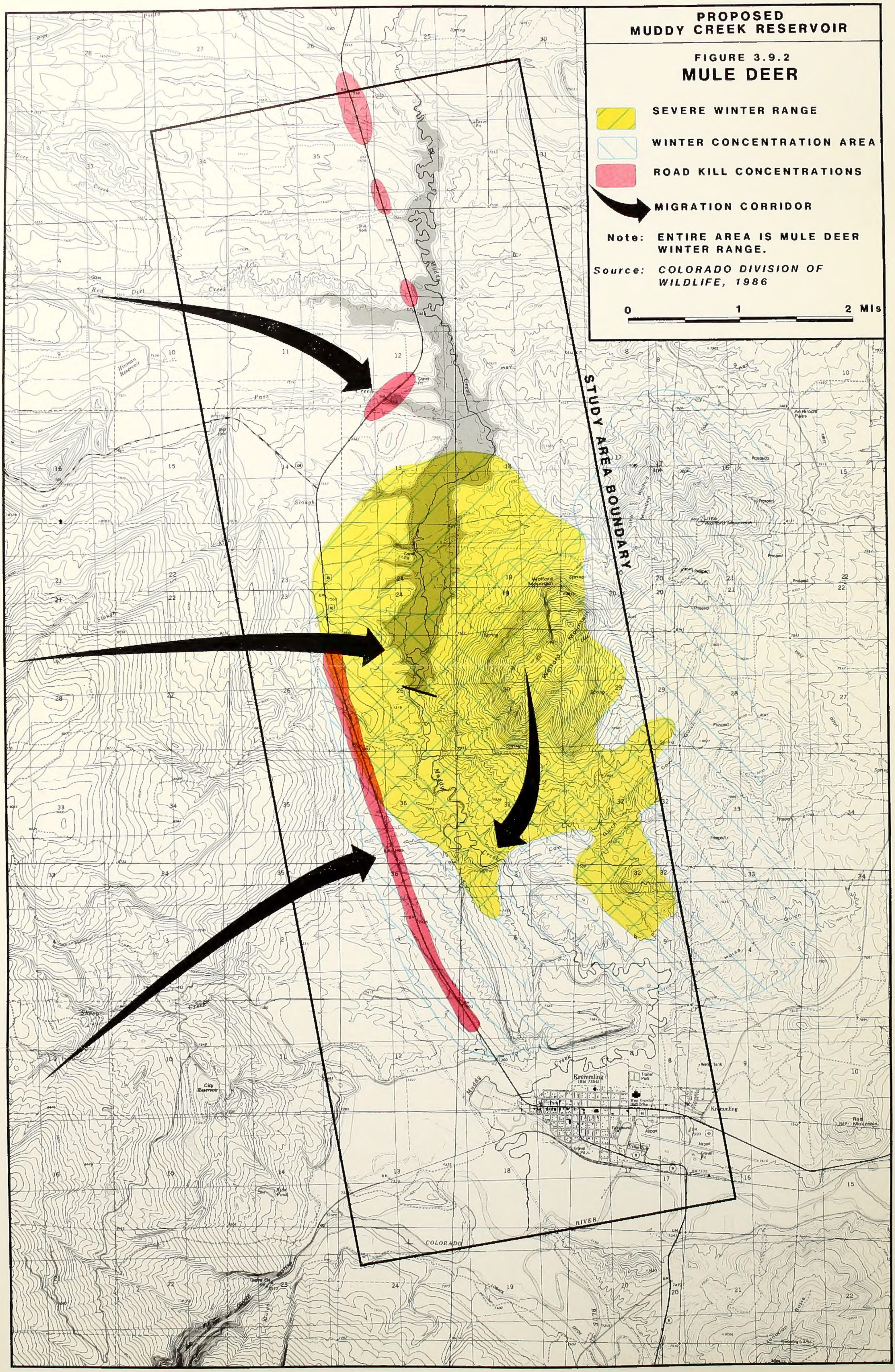
and snow characteristics to the study area. The winter of 1983-84 is an example of extremely severe wintering conditions for big game when snowfall was in excess of 50 inches by mid-December and averaged over 100 inches during late-December through March (Freddy, 1986). The average minimum temperature for January was -18°F. An example of a mild winter occurred in 1980-81 when the ground was essential free of snow for the entire winter and temperatures were far above normal. Winter conditions near Muddy Creek were judged to be severe in 3 of the last 20 winters (Carpenter et al., 1984). A direct relationship exists between winter severity and big game survival over the winter (Hugie, 1973). During a very severe winter, such as 1983-84, mule deer fawn mortality can be as high as 90 percent and adult mortality can exceed 30 percent (Carpenter et al., 1984).

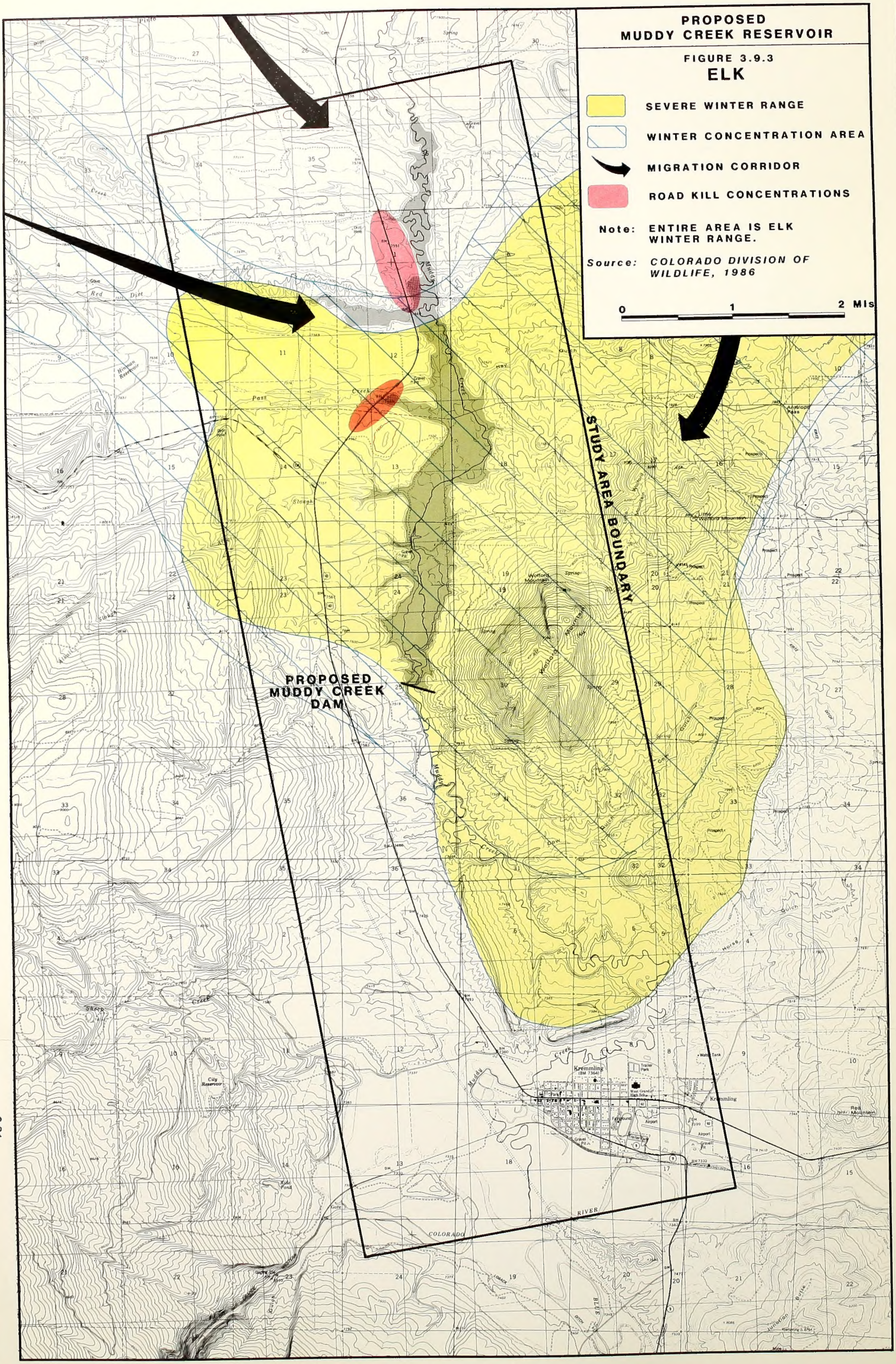
Snow depth influences energy expenditure and food availability (Carpenter et al., 1984). Extensive periods of snow depths greater than 11 inches for mule deer and 17 inches for elk (Parker et al., 1984) appear to be critical levels beyond which the utility of the habitat is severely decreased and high mortalities are likely to occur. The behavioral adaptation by these species to form trails in the snow can modify the energy utilized for snow travel (Parker et al., 1984). In Middle Park, Gilbert et al. (1970) found 88.7% of deer observed in areas of snow depths less than 18 inches.

Figures 3.9.2 and 3.9.3. show the different types of winter range (Schnurr, 1985) for mule deer and elk, respectively, in the Muddy Creek study area. The figures show the general pattern of winter range and do not reflect small variations in use patterns that generally occur. The most critical range (severe winter range and winter concentration areas) is along Muddy Creek near its lower end, and on the uplands and ridges just above Kremmling. This is the area used during the later stages of many winters and during very severe winters. Its major feature is lower snow depth and exposed slopes, whereas range condition is generally poor to fair. Less critical range (classified as winter range by the CDOW) occurs north of the critical range and is used in early to mid-winter and winter-long during mild winters. It typically has fairly deep snow depth in late winter, poor to fair range condition, with limited exposed slopes.

Other factors influencing wintering populations of mule deer and elk in the study area include ranching practices and highways. Colorado Highway 40 bisects several migratory routes into the wintering area, resulting in "zones" of highway mortalities (Figure 3.9.2). Kills of 20 to 40 mule deer per year, as well as a few elk, on Highway 40 north of Kremmling are common (Freddy, 1986). The highest concentration of deer kills appears to be about 3-4 miles northwest of Kremmling on Highway 40. Daily movement patterns across Highway 40 also contribute to vehicle/deer or elk collisions. Much of this movement is between daytime resting areas and nighttime feeding areas, generally local ranchers' haystacks.

Several avian game species also are found within the study area. Sage grouse occupying the area are part of Small Game Management Unit (SGMU) 28. This unit is comprised of 77 square miles of winter range, 260 square miles of nesting habitat, 0.1 sq. miles of brooding habitat, 9.81 square miles of historic habitat, and 355 square miles of general use habitat (Schnurr,


PROPOSED
MUDDY CREEK RESERVOIR
FIGURE 3.9.2
MULE DEER
SEVERE WINTER RANGE
WINTER CONCENTRATION AREA
ROAD KILL CONCENTRATIONS
MIGRATION CORRIDOR
Note: ENTIRE AREA IS MULE DEER WINTER RANGE.
Source: COLORADO DIVISION OF WILDLIFE, 1986
0 1 2 MIs
STUDY AREA BOUNDARY
Kremmling
COLORADO RIVER


PROPOSED
MUDDY CREEK RESERVOIR
FIGURE 3.9.3
ELK
SEVERE WINTER RANGE
WINTER CONCENTRATION AREA
MIGRATION CORRIDOR
ROAD KILL CONCENTRATIONS
Note: ENTIRE AREA IS ELK WINTER RANGE.
Source: COLORADO DIVISION OF WILDLIFE, 1986
0 1 2 MIs
STUDY AREA BOUNDARY
PROPOSED
MUDDY CREEK
DAM
Kremmling
COLORADO
RIVER

1985). Winter range and two lek sites (historical spring breeding areas) within the study area (Figure 3.9.4) are considered critical habitat by the CDOW. Most of the study area is considered summer range. Blue grouse may occur on Wolford Mountain, but documentation is not available (USDI, 1984). Several species of waterfowl breed along the riparian and wetland areas of Muddy Creek. The Muddy Creek drainage affords good, but limited, waterfowl hunting (Freddy, 1986). Morning doves breed within the study area and provide a fall hunting opportunity.

Several terrestrial and aquatic furbearers are found within the study area. Beaver and muskrat can be found along Muddy Creek and have been harvested in past years (Freddy, 1986). Although numbers of beaver in the study area have been high in the past, current habitat only supports low densities (<1 lodge/linear stream mile). No fresh beaver sign was noted during a recent wildlife study within the proposed reservoir basin (Pekins and Hugie, 1986). Coyotes, bobcats, weasels and badgers are found within the study area in moderate to low densities.

The Muddy Creek study area provides habitat for numerous species of non-game birds and small mammals. Non-game birds observed during field studies conducted in June 1986 included over 25 species of passerines and representatives from an additional nine avian orders. A few snags are scattered throughout the area, while cliff and bank nesting habitat is plentiful. Small mammals include several species of rodents, chipmunks, and ground squirrels. The non-game birds and small mammals provide a forage base for several terrestrial and avian predators.

Raptors found in the study area include American kestrels, prairie falcons, red-tailed hawks and golden eagles. Nests were found for these species during spring surveys in 1986 (Kung, 1986). In addition, several raptor species use the area during migration but do not nest or remain within the study area.

3.9.2.2. Threatened and Endangered Species. The federally endangered bald eagle winters along the Colorado River south of the proposed project area. A single bald eagle was sighted in the northern portion of the study area during January 1986 (Chanson, 1986). Bald eagles often feed on big game carrion, but are usually associated with open water as fish provides an important forage base.

Peregrine falcons, also a federally endangered species, are known to migrate through Middle Park. Potential nesting habitat exists for the species in the study area along Wolford Mountain but no nests have been reported (USDI/BLM, 1984). The study area also contains potential feeding habitat.

The irrigated and dry meadows along Muddy Creek provide potential feeding and resting areas for greater sandhill cranes, a state endangered species, which has been sighted in the area (Freddy, 1986).

1985). Winter range and two elk (historical) spring [illegible] areas within the study area (Figure 3.8.3) are considered critical habitat by the CDOW. Most of the study area is considered summer range. Blue grouse may occur on [illegible] Mountain, but documentation is not available (Holt, 1979). Several species of waterfowl breed along the riparian and wetland areas of Muddy Creek. The Muddy Creek drainage affords good, but limited, waterfowl hunting (Grady, 1980). Canada geese breed within the study area and provide a fall hunting opportunity.

Several terrestrial and aquatic furbearers are found within the study area. Beaver and muskrat can be found along Muddy Creek and have been harvested in past years (Grady, 1980). Although numbers of beaver in the study area have been high in the past, current [illegible] (Grady, 1980). [illegible] within the proposed [illegible] and [illegible] (1980). Coyotes, bobcats, weasels and badgers are found within the study area in moderate to low densities.

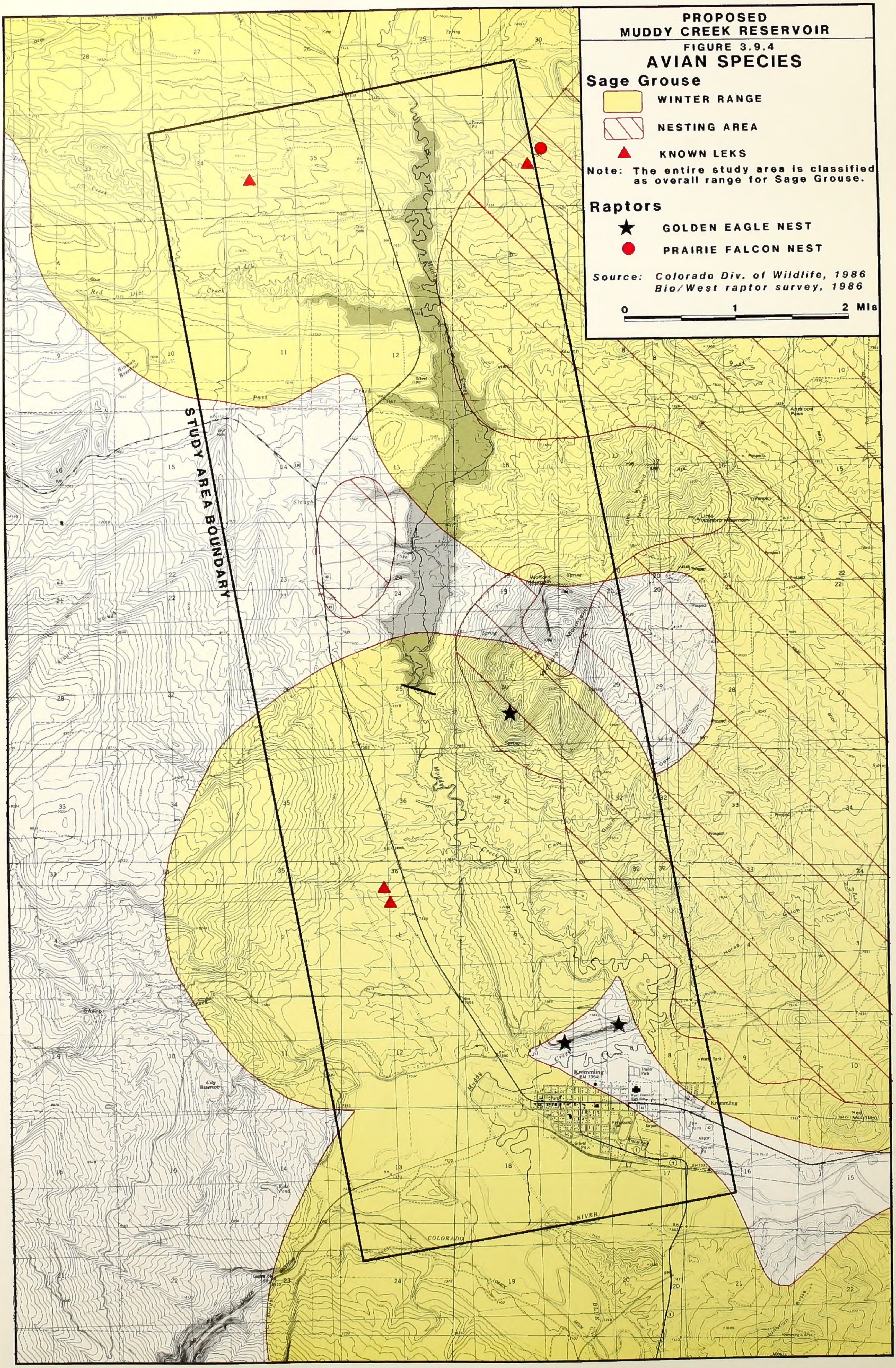
The Muddy Creek study area provides habitat for numerous species of nongame birds and small mammals. Non-game birds observed during field studies conducted in [illegible] 1979 included over 70 species of waterfowl and representatives [illegible] avian orders. [illegible] throughout the area, while cliff and hawk [illegible]. Small mammals include several species of chipmunks, [illegible] and ground squirrels. The non-game birds and small mammals provide a prey base for several terrestrial and avian predators.

Raptors found in the study area include American kestrels, [illegible], red-tailed hawks and golden eagles. Nests were found for these species during raptor surveys in 1980 (Grady, 1980). In addition, several raptor species use the area during migration but do not nest or remain within the study area.

3.8.1.2 Threatened and Endangered Species. The federally endangered bald eagle winters along the Colorado River south of the proposed project area. A single bald eagle was sighted in the northern portion of the study area during January 1981 (Johnson, 1981). Bald eagles [illegible], but are usually associated with open water or fish [illegible] or [illegible].

Peregrine falcons, also a federally endangered species, are known to migrate through Middle Park. Potential nesting habitat exists for the species in the study area above [illegible] but no active nests have been reported (Johnson, 1981). The study area also contains potential foraging habitat.

The intermittent wet meadows along Muddy Creek provide potential feeding and nesting areas for greater sandhill cranes, a state endangered species, which has been sighted in the area (Grady, 1980).



PROPOSED
MUDDY CREEK RESERVOIR
FIGURE 3.9.4
AVIAN SPECIES
Sage Grouse
WINTER RANGE
NESTING AREA
KNOWN LEKS
Note: The entire study area is classified as overall range for Sage Grouse.
Raptors
GOLDEN EAGLE NEST
PRAIRIE FALCON NEST
Source: Colorado Div. of Wildlife, 1986
Bio/West raptor survey, 1986
0
1
2 Mls
STUDY AREA BOUNDARY
Kremmling
COLORADO
RIVER

3.10. Land Use Plans and Ownership

3.10.1. Rock Creek. The Rock Creek area is primarily managed by the USFS (Routt National Forest). A small portion of private land occurs near the confluence of Rock Creek and Jolly Creek (Fig. 3.10.1), and also in Long Park, about five miles southwest of the proposed Rock Creek Dam Site. The private land is committed to summer livestock grazing. The State of Colorado also owns 191 acres along Rock Creek just below the confluence with Jolly Creek (Fig. 3.10.1). Recreational activities at this site include hunting, fishing, camping, hiking, cross country skiing, and snowmobiling.

Management direction for the National Forest System land is found in the Forest Plan (USDA/FS, 1983), which stipulates that State water quality standards must be maintained, but temporary violations may be allowed under certain conditions. Authorized uses of National Forest System lands must allow for maintenance of specific instream or bypass flows as determined by USFS needs. This should include volumes necessary to maintain stream channel stability and capacity even in the event of increased use. The general goals of the plan include the protection of all bodies of water such as lakes and streams and the surrounding soils and riparian vegetation. This goal constitutes both protection of the resource and preservation of its productivity. However, the Forest Plan does allow for water development projects following a detailed environmental analysis of the affected area.

National Forest System lands in the affected environment are broken into Forest Service management prescriptions (USDA/FS, 1983) 2B, 3A, 4B, and 9B (Fig. 3.10.2). Management prescription 2B emphasizes rural and roaded natural recreation opportunities. Motorized and unmotorized activities are allowed, but motorized travel may be restricted to designated routes or prohibited in some areas. Vegetative treatment includes clearcuts and shelterwood cuts in specified cover types.

Management prescription 3A emphasizes semi-primitive unmotorized recreation in roaded and nonroaded areas. Restrictions on human use may occur to protect critical wildlife areas. Roads are closed to public use, but compatible resource use (e.g. grazing, mineral development) occurs. Clearcutting and shelterwood cuts are allowed in specific cover types. Management prescription 4B emphasizes habitat for management indicator species by optimizing habitat capability. Semi-primitive motorized and nonmotorized recreation activities occur, with motorized recreation being restricted to local roads and trails that remain open. Compatible resource use is allowed, but is not a primary goal. A variety of tree harvesting and vegetation management practices are used to improve wildlife habitat.

Management prescription 9B emphasizes increased water yield and improved timing of flow through vegetation treatment. Recreation opportunities are predominantly semi-primitive with prohibitions on motorized travel allowed by the USFS. Livestock grazing occurs as long as it does not impair the primary prescription goal. Tree harvesting is performed with clearcuts.

3.10. Land Use Plans and Ownership

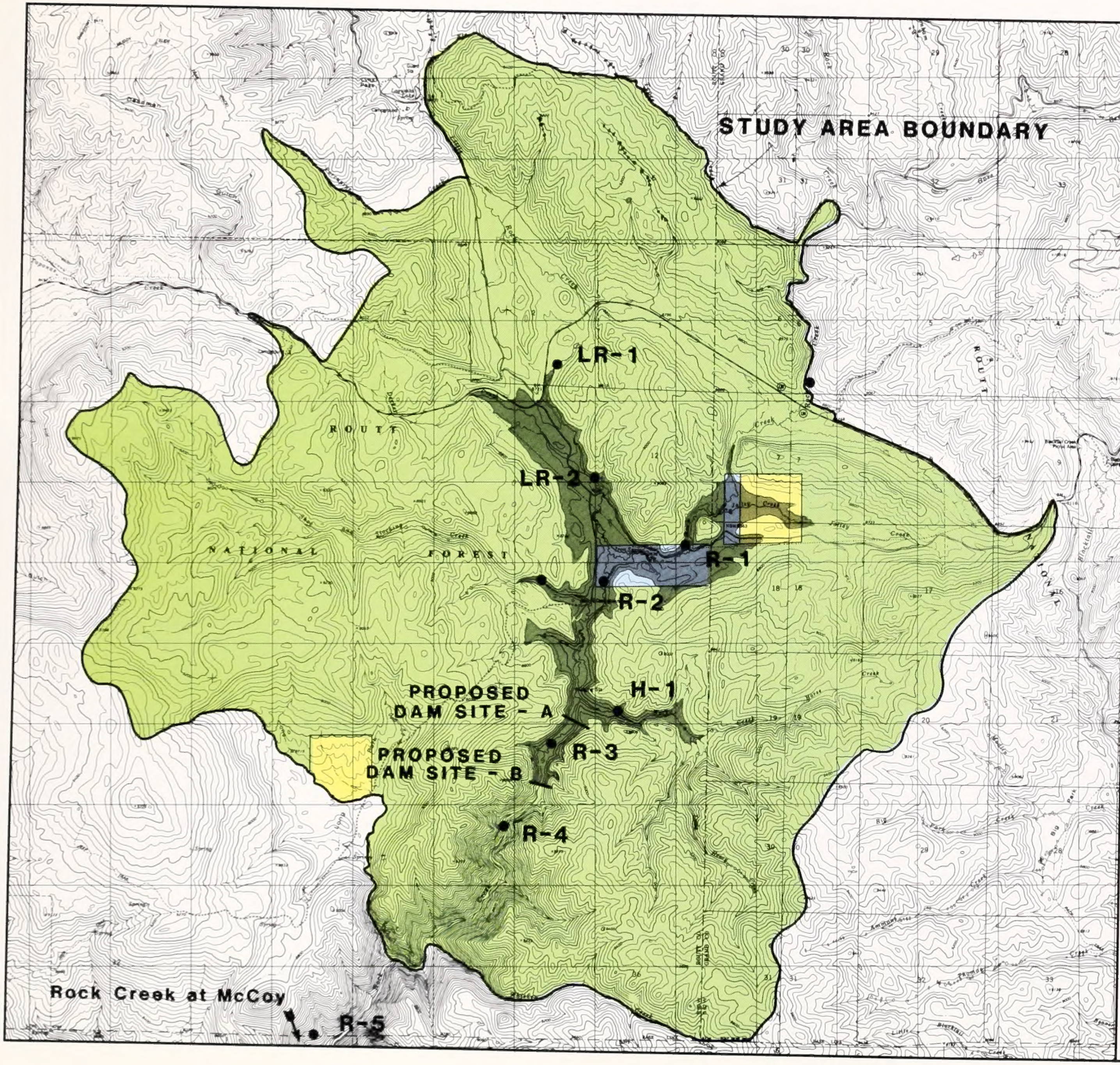
3.10.1. [illegible]. The Tenn Creek area is primarily managed by the [illegible] (Mount Hood National Forest). A small portion of private land occurs near the confluence of Tenn Creek and Jolly Creek (Fig. 3.10.1), and also in [illegible], about [illegible] miles downstream of the proposed Tenn Creek dam site. The private land is committed to present livestock grazing. [illegible] along Tenn Creek just below the confluence with Jolly Creek (Fig. 3.10.1). Recreational activities in this area include hunting, fishing, camping, hiking, cross country skiing, and snowmobiling.

Management direction for the National Forest System land is based on the Forest Plan (USDA FS, 1988), which stipulates that [illegible] water quality standards must be maintained, but temporary violations may be allowed under specific conditions. Authorized uses of National Forest System lands must allow for maintenance of specific instream [illegible] flows as determined [illegible]. This would include [illegible] channel stability and capacity [illegible]. The general goals of the plan include the protection of [illegible] and the surrounding [illegible]. [illegible] protection of the resource and [illegible]. However, the Forest Plan does allow for development projects following a detailed environmental analysis of the affected area.

National Forest System lands in the affected environment are managed [illegible] management prescriptions (USDA FS, 1988, [illegible]). Management prescription [illegible] emphasizes [illegible] recreation opportunities. Motorized and nonmotorized travel may be [illegible] in designated areas. Vegetative [illegible] includes [illegible] to maintain [illegible] types.

[illegible] emphasizes [illegible] and [illegible] areas. [illegible] are closed to [illegible]. [illegible], grazing, [illegible] development [illegible] are allowed to [illegible] types. [illegible] habitat for [illegible] and [illegible] capabilities. [illegible] with [illegible] roads and trails [illegible]. [illegible] is a [illegible] goal. A variety of [illegible] and [illegible] management practices are used to improve [illegible].

[illegible] of [illegible] increased water yield and [illegible]. [illegible] with [illegible] prescriptions [illegible]. [illegible] grazing [illegible] as long as it does not impede the primary [illegible] goals. [illegible] harvesting is [illegible] with [illegible].



PROPOSED
ROCK CREEK RESERVOIR

Figure 3.10.1
**LAND OWNERSHIP
&
FISH SAMPLING SITES**

NATIONAL FOREST

STATE OF COLORADO

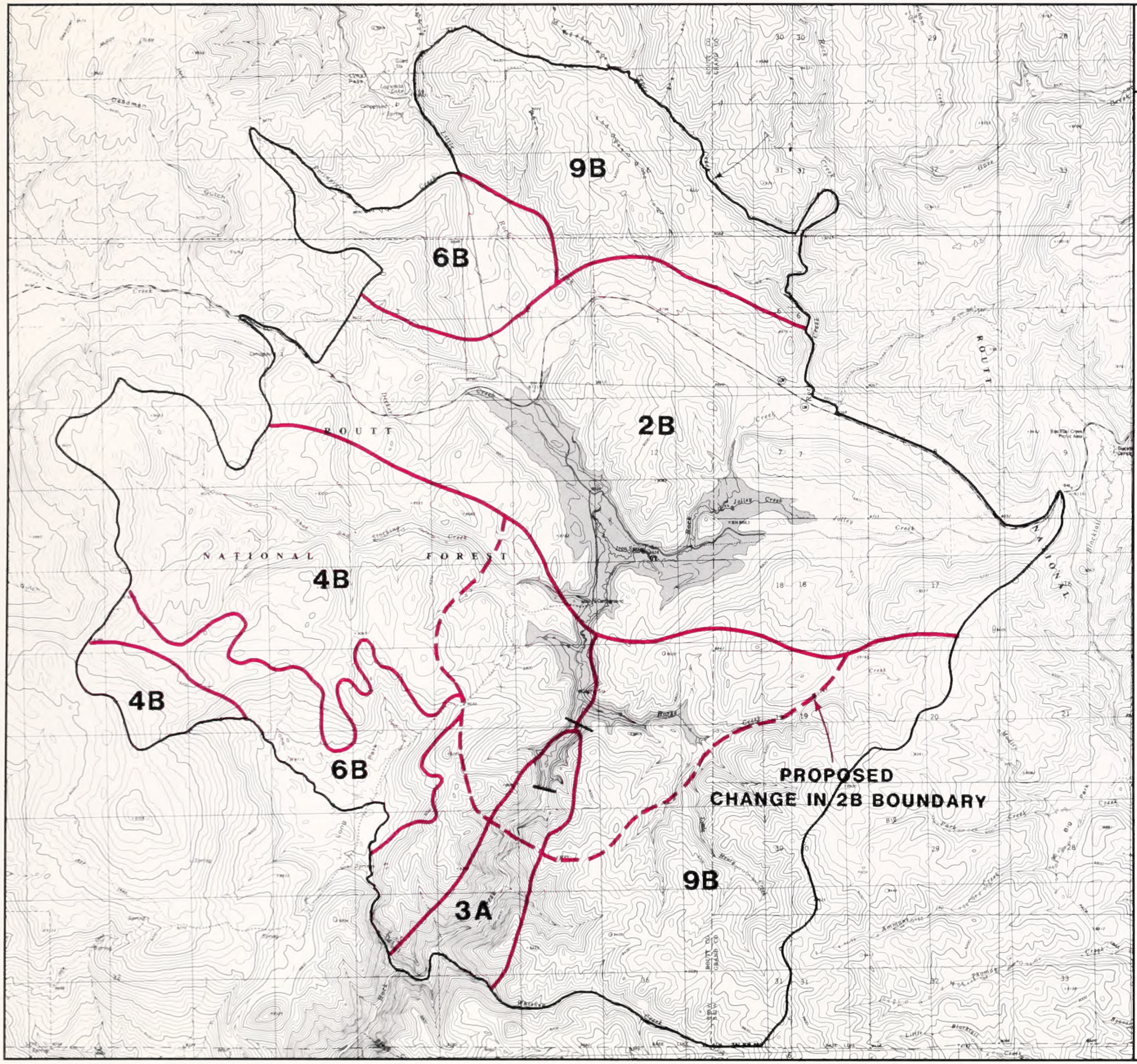
PRIVATE

• FISH SAMPLING SITES

(Source: B.L.M., 1985)

N

0 1 2 Miles



PROPOSED ROCK CREEK RESERVOIR

Figure 3.10.2 MANAGEMENT AREA DIRECTION CLASSES

2B. MANAGEMENT AREA - Emphasizes rural and roaded natural recreation opportunities such as driving for pleasure and viewing scenery and snowmobiling. Management activities may remain visually subordinate or dominate. Timber harvest includes clearcutting and shelterwood and will enhance visual quality, recreation setting, and wildlife habitat diversity.

3A. MANAGEMENT AREA - Emphasizes semiprimitive nonmotorized recreation such as hiking or cross country skiing in roaded or nonroaded area. Roads are closed except for main roads through the areas or roads open at specific times. Management activities are visually subordinate. Timber harvest includes clearcutting, shelterwood, and selection.

4B. MANAGEMENT AREA - Emphasizes wildlife habitat management for one or more indicator species. Semiprimitive motorized recreation opportunities will be provided, but vegetation manipulation and human activities are managed to provide optimum habitat for the selected species.

6B. MANAGEMENT AREA - Emphasizes improving and/or maintaining rangeland. Improvements may include seeding, burning, spraying, crushing, or plowing as well as structural improvements.

9B. MANAGEMENT AREA - Emphasizes increased water yield through vegetative treatment such as clearcutting.

SOURCE: Routt National Forest Land and Resource Management Plan, 1983.

0 1 2 Miles

Development on National Forest System land requires a Special Use Permit which is authorized only if suitable land is available and the proposed project is compatible with USFS management goals and public interest is satisfied (USDA/FS, 1983).

3.10.2. Muddy Creek. The Muddy Creek area is a mixture of private land along Muddy Creek and its tributaries, and public land managed by the BLM in the upland areas around the stream (Fig. 3.10.3). The BLM holdings are classified as Category I lands, which are those lands needed for multiple use management and not under consideration for disposal. The public lands are managed according to the Resource Management Plan for the Kremmling Resource Area (USDI/BLM, 1984), which indicates the lands in the study area are within a livestock grazing property area committed to livestock grazing and the production of livestock forage. Other uses would be permitted as long as they did not significantly interfere with livestock grazing or range management. This use could include dispersed and developed recreation, major realty actions, and the protection or improvement of critical wildlife habitat through management. Use on private land is similar, with ranching, livestock grazing, and hay production the major activities. Additional use of the study area involves limited recreational opportunities, primarily off-road vehicular (ORV) snowmobiling and hunting. The affected private lands are zoned as F (Forestry) and O (Open) by Grand County.

Development on BLM land requires a use authorization that must satisfy three criteria (USDI/BLM, 1984): project supports local or regional needs, use of public lands is the most environmentally and economically suitable, and application for use satisfies all legal requirements.

3.11. Grazing

3.11.1. Rock Creek. Portions of three USFS cattle and horse grazing allotments are within the Rock Creek study area. These include the Coberly-Maudlin, Horse Creek and Blacktail allotment. All three allotments have been fully stocked and utilized within the past 10 years by the various leasees. The name, type of allotment, AUMs involved, season length and capacities for each of the three allotments within the study area are summarized in Table 3.11.1. All three allotments are used mainly during July through September or early-October.

3.11.2. Muddy Creek. Portions of ten BLM cattle grazing allotments are within the Muddy Creek study area. Sizes of the potentially affected allotments vary from 342 to 7,722 acres. Specific information on size, AUMs and length of grazing season for each allotment is presented in Table 3.11.2. Most of the allotments have been fully stocked within recent years and are operated by several leasees. The season of use varies for each allotment but generally the potentially affected allotments are used during spring and summer months (USDI/BLM, 1984).

Development on National Forest System land requires a Special Use Permit which is authorized only if suitable land is available and the proposed project is compatible with USFS management goals and public interest is satisfied (USDA-FS, 1983).

3.10.2. Muddy Creek. The Muddy Creek area is a mixture of private land along Muddy Creek and its tributaries, and public land managed by the BLM in the upland areas around the stream (Fig. 3.10.2). The BLM holdings are classified as "Category I Lands, which are those lands needing the multiple use management and the where consideration is proposed. The public lands are managed according to the Resource Management Plan for the Kemmerer Resource Area (USDI-BLM, 1984), which indicates the lands in the study area are within a livestock grazing property area classified for livestock grazing and the production of livestock forage. Other uses would be permitted as long as they did not significantly interfere with livestock grazing or range management. This use could include dispersed and developed recreation, water yield actions, and the protection or improvement of critical wildlife habitat through management. Use of private land is similar, with ranching, livestock grazing, and hay production the major activities. Additional use of the study area involves limited recreational opportunities, primarily off-road vehicular (ORV) recreation and hunting. The affected private lands are zoned as F (Forestry) and A (Agric) by Uinta County.

Development on BLM land requires a use authorization that must satisfy three criteria (USDI-BLM, 1984): project supports local or regional needs, use of public lands is the most environmentally and economically suitable, and application for use satisfies all legal requirements.

3.11. Grazing

3.11.1. Rock Creek. Portions of three USFS cattle and horse grazing allotments are within the Rock Creek study area. These include the Gunsight-Rasmuzin, Salsa Creek and Blacktail allotments. All three allotments have been fully stocked and utilized within the past 10 years by the various lessees. The name, type of allotment, AUMs permitted, season length and acreage for each of the three allotments within the study area are summarized in Table 3.11.1. All three allotments are used only during early summer to September or early-October.

3.11.2. Muddy Creek. Portions of two BLM cattle grazing allotments are within the Muddy Creek study area. Sizes of the potentially affected allotments vary from 342 to 7,712 acres. Specific information on size, AUMs and length of grazing season for each allotment is presented in Table 3.11.2. Most of the allotments have been fully stocked with cattle herds which are operated by several lessees. The season of use varies for each allotment but generally the potentially affected allotments are used in the spring and summer months (USDI-BLM, 1984).

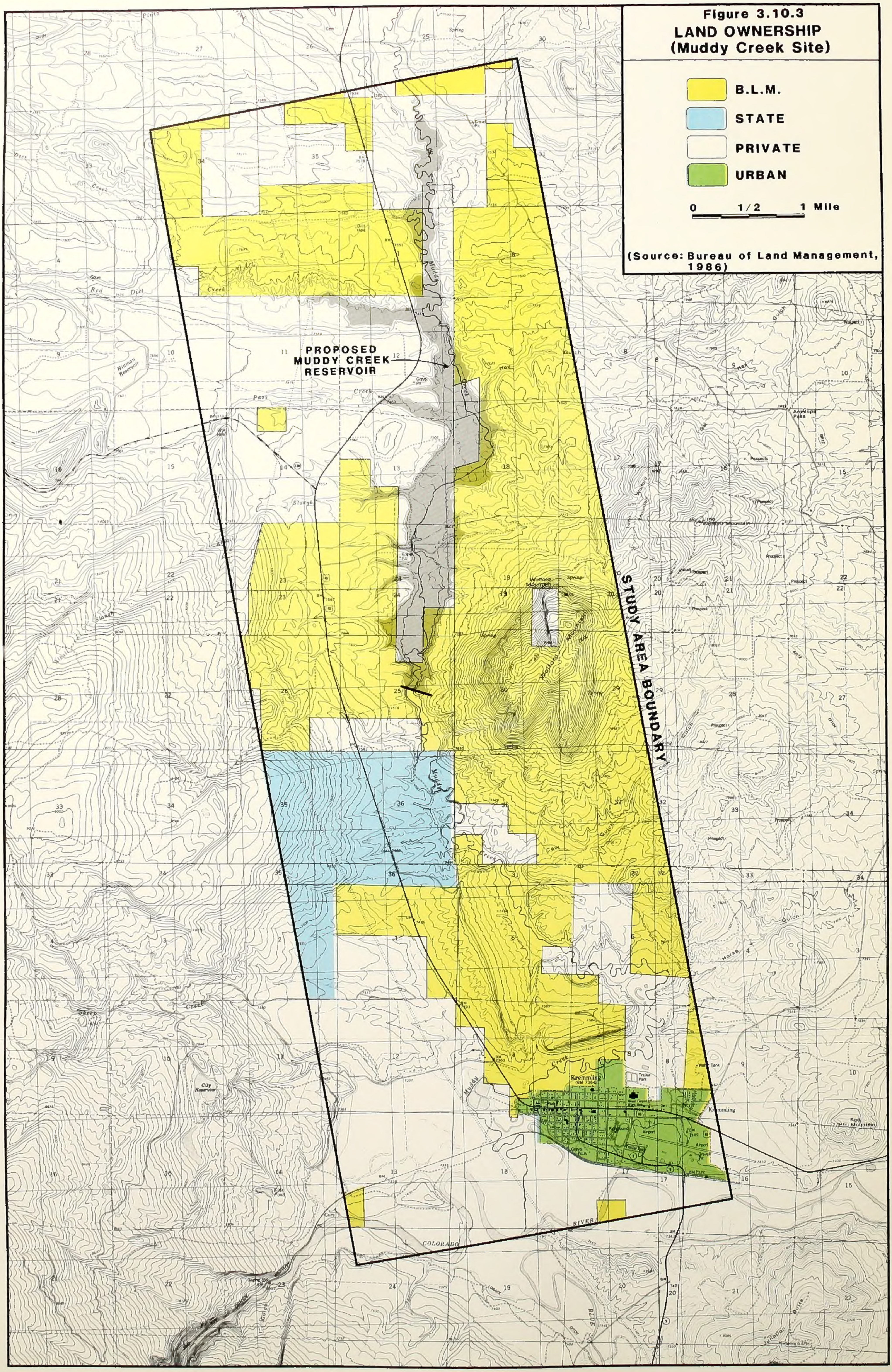


Figure 3.10.3
LAND OWNERSHIP
(Muddy Creek Site)

Table 3.11.1. Grazing allotments in Routt National Forest potentially affected by the proposed Rock Creek Reservoir.

	Allotment					
Allotment Name/Type	Gross Acres	AUMs	Season Length	Capacity/ Season	Percent Suitable	S.A/ AUM
Horse Ck/ C & H	8960	679	100	165 ccu	45.2	5.96
Coberly-Maudlin/ C & H	13482	1180	90	644 ylg	46.0	5.25
Blacktail/ C & H	28060	1467	75	480 ccu	22.4	4.28

C & H= Cattle and Horse Allotment
ccu= Cow/Calf Unit
ylg= Yearling cattle
S.A.= Suitable Acres
AUM= Animal Unit Month, where a cow with calf is equal to 1 and a yearling is equal to 0.5.

Table 3.11.2. BLM grazing allotments potentially affected by the proposed Muddy Creek Reservoir near Kremmling, Colorado.

	Allotment					
Allotment Name/Type	Gross Acres	AUMs	Season Length	Capacity/ Season	Percent Suitable	S.A/ AUM
7506/C	7722	36	230	362	ALL	21
7532/C	403	24	75	10	ALL	17
7540/C	1264	211	204	31	ALL	6
7550/C	1370	141	35	117	ALL	10
7754/C	2268	414	120	104	ALL	5
7568/C	6741	1600	120	400	ALL	29
7760/C	676	70	180	12	ALL	10
7764/C	342	51	60	25	ALL	7
7765/C	1075	118	60	59	ALL	9
7784/C	996	108	30	108	ALL	9

C = Cattle
S.A.= Suitable Acres
AUM = Animal Unit Month, where a cow with a calf is equal to 1.
Source: (USDI/BLM, 1984)

Four privately owned ranches within the study area graze cattle along the bottomlands and sidehills of the Muddy Creek drainage. These privately owned lands also serve as the base property for various BLM and USFS lease allotments. In order for ranchers to use federal leases they usually must show that they own or control other privately owned property that serve as bases for their livestock operations. The private ranches also use some of their land to raise hay, as calving areas and as feeding grounds for overwintering stock.

3.12. Visual Resources

3.12.1. Rock Creek. The Rock Creek drainage basin (median elevation 8,600 feet) is enclosed by mountains which range in elevation from 9,000 feet to 9,500 feet. Colorado Highway 134 crosses the northern edge of the drainage. The principal viewshed into the proposed reservoir site is from this highway, particularly the section just east of Decker Creek. This highway receives moderate use (Costello 1985); many highway users are recreationists for whom the quality of the visual resource is important as evidenced by the U.S. Forest Service sensitivity rating of 1. Motorists on Highway 134 are in an observer normal or slightly superior position relative to the area. From most locations along Highway 134, the foreground and middle ground components of the viewshed are significant.

The Rock Creek area is used to varying degrees by recreationists on a year-round basis. Primary users during the summer months are fishermen and campers; use during the weekend is heaviest (See Recreation Section). In the fall, deer and elk hunters use the area for base camps. Winter use of the area by snowmobilers is substantial, particularly on weekends. Cross-country skiers and snowshoers also make limited winter use of the area. The visual quality of the resource is of considerable importance as a part of the recreational experience for each of these user groups.

For hikers, campers, and other recreators within the drainage the views are dominated by the foreground (sagebrush/grass - evergreen interface). The middle ground views are of receding stands of lodgepole pine rising in elevation and are typical of the area. Distant views to the North and Southeast are of high visual quality. The entire area has an implied sense of enclosure and self-containment. The viewer is in an inferior observer position.

The upper half of the drainage is oriented Northwest-Southeast and varies from 0.5 to 0.75 of a mile in width between enclosing slopes. Soil color in the drainage is buff gray to buff red. Vegetation on the basin floor is dominated by a sagebrush/grass association. A lineal strip of riparian and sub-irrigated vegetation (willow-riparian) meanders in a serpentine pattern across the basin floor. Rock Creek and Jolley Creek are lineal focal elements that add substantially to the visual diversity of the area.

Four cultural features are of visual importance to the upper basin area. A powerline (double pole standards) traverses the length of the upper meadow as does an unimproved, moderately used gravel road. Highway 134 is

visible in several locations along the northern edge of the upper basin. The Rock Creek Stage Station resides on an open slope along the north edge of the meadow; it is both a cultural and visual landmark.

The uplands that enclose the basin floor range in slope from 15% to 40%. These slopes are densely forested; the predominant species is lodgepole pine with some interspersion of aspen and spruce. The edge condition between the pine clad uplands and the basin floor meadow is feathered and extensive; diversity in line, form, and pattern are high. Evidence of cultural disturbance (past logging activity) is visible from the gravel road that traverses the basin floor.

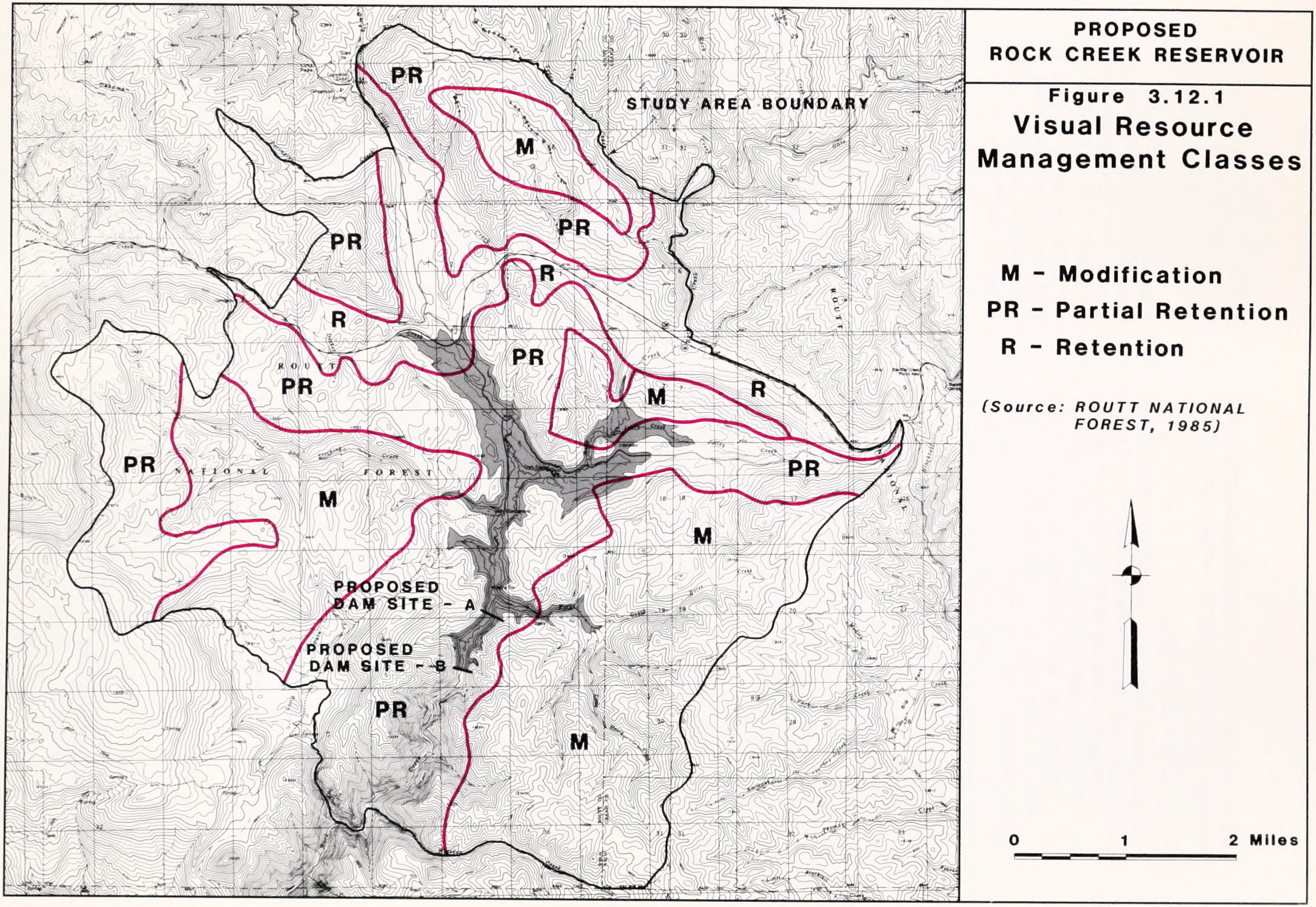
The lower section of the basin downstream from the existing campgrounds is oriented north-south and varies from 0.25 to 0.5 miles in width. The enclosing slopes vary from 25% to 45%. Bedrock outcroppings occur in several locations. Soil color varies from buff gray to buff red and when exposed contrasts sharply with adjacent undisturbed sites. The south end of the drainage near the proposed dam site is strongly enclosed by the adjacent uplands.

Hydric growing conditions created by numerous beaver dams have allowed riparian and sub-irrigated vegetation (willow) to dominate this section of the drainage. Rock Creek, Little Rock Creek, and associated beaver dams are the dominant visual amenity. However, grasses are also a visually significant part of the pattern. Grasses and some willow extend up side drainages such as Horse Creek and Shoe and Stocking Creek creating a subtly diverse pattern. The level of vegetative interspersion is moderate to high, hence visual diversity is moderate to high. The uplands in this section, as in the upper section, are dominated by evergreen vegetation, predominantly lodgepole pine. The pine to sagebrush/grassland interface is feathered, creating a moderate level of visual diversity in upland areas.

Landscape architects with the Routt National Forest have completed a visual resource inventory for the general area (Fig. 3.12.1). Approximately 85% of the affected area is within Visual Resource Management Classification 1, Partial Retention. A small section adjacent to Highway 134 is classified as a Retention zone and another small section north of Jolley Creek is classified Modification.

3.12.2. Muddy Creek. The Muddy Creek drainage basin (median elevation 7,500) is a moderately sloping and broken sagebrush/grass dominated segment of high mountain plains landscape. The creek is incised into the adjacent plain; depth of river downcutting varies from 30 feet at the Pinto Creek confluence to 200 feet near Kremmling. The width of the Muddy Creek channel (historical) varies from 0.10 mile in upstream segments to 0.50 mile near Kremmling. Wolford Mountain and Little Wolford Mountain are the dominant landmarks in this otherwise moderate landscape. The mountain backdrop to the north, south and west is visually significant.

The principal viewshed into the proposed reservoir site is from U.S. Highway 40 (US 40) which parallels Muddy Creek to the west and is elevated above the creek. The highway receives moderate to heavy use from both


PROPOSED
ROCK CREEK RESERVOIR
Figure 3.12.1
Visual Resource
Management Classes
M - Modification
PR - Partial Retention
R - Retention
(Source: ROUTT NATIONAL
FOREST, 1985)
0
1
2 Miles
STUDY AREA BOUNDARY
PR
M
PR
PR
R
R
PR
PR
M
R
PR
M
M
PR
PROPOSED
DAM SITE - A
PROPOSED
DAM SITE - B
PR
M
ROUTT
NATIONAL
FOREST

recreational and commercial traffic, consequently the quality of the visual resource is of importance to a substantial number of the motorists traveling this route.

Motorists are in an observer superior position. In most cases the foreground and middle ground components of the viewshed from the highway are significant (rated as high sensitivity on the BLM Visual Resource Management [VRM] Plan). However, because of viewing distance and the incised stream channel, Muddy Creek itself and much of the irrigated pasture are infrequently seen, particularly in the southern half of the area. Similar viewing characteristics are available to the limited number of motorists that use the gravel roads east of Muddy Creek.

At present, the area is used as rangeland and for forage production. Recreation use is minimal. For ranchers and a limited number of recreationists views from within the drainage looking out are seen from an observer inferior position. The foreground of these views is dominated by stream bank soils (gray in color), riparian vegetation and the pattern of irrigated pasture. The middle ground views of sage/grass vegetation is typical of the area. Distant views, particularly to the north, south and of Wolford Mountain are of high quality. The southern half of the affected environment is enclosed by adjacent topography; the sense of enclosure declines in the upstream segment of the site.

The Muddy Creek drainage basin is oriented north-south. The enclosing uplands slope to the east and west toward the creek at an average grade of 10%, then drop abruptly to the historic floodplain. The banks defining the present stream channel slope steeply (average 75%) from top of slope to waters edge. The stream banks are generally unstable and the gray to gray-brown soils are typically exposed. Vegetation on the steeply sloping banks is sparse and is typically willow-cottonwood. Most of this vegetation is concentrated along tight river bends, and the adjacent shrub areas have been heavily browsed. Several cutoff oxbows support substantial stands of aquatic vegetation. Because of constant erosion, Muddy Creek is very turbid and the stream channel meanders throughout its entire length within the study area. Soil color is visually dominant along the stream channel.

Vegetation within the historical flood plain is dominated by grasses (irrigated hay meadows), which are irregular in form. The green color of the meadows contrasts sharply with the gray-green to sandy-brown colored uplands. Vegetation on the upland topography is dominated by sagebrush with associated grasses and forbs. Although sparse, this vegetative pattern is relatively uniform with depressions and shallow drainages creating a somewhat corrugated effect. The visual pattern of vegetation is typical of the area, however it is broken where irrigation occurs and other range management practices have been employed. The buff gray soil color of the steeper slopes which drop from the uplands to the historical flood plain dominate much of the foreground and middle ground viewshed when seen from US 40.

Numerous cultural elements, including US 40, several lightly used gravel roads and a major power transmission line (wooden pylon towers) are important visual features in the affected environment. The transmission

line which crosses Muddy Creek and US 40 approximately 3.0 miles north of Kremmling is a particularly dominant element. Cultural features of secondary visual importance include powerlines (single standard, wooden towers), fences, ranch buildings, and gravel pits.

The southern segment of Muddy Creek below the proposed dam site and its associated flood plain (although not readily visible from U.S. 40) constitutes a distinctively different visual resource as seen from within the proposed reservoir site. The stream section immediately north of Kremmling is clearly delineated by dense riparian vegetation and meanders through a series of geometric pastures creating a high level of visual contrast. Enclosing slopes along this section, including many with distinctive rock outcroppings, heighten the area's visual quality. This section of Muddy Creek is visually the most striking of any within the affected environment.

The northern segment of Muddy Creek, west and north of Wolford Mountain, is visually dominated by eroded banks that delineate the basin floor. The enclosing element of adjacent topography is of minimal significance. Riparian vegetation is sparse and has been heavily browsed. The level of vegetative interspersion is low, hence visual diversity is low to moderate.

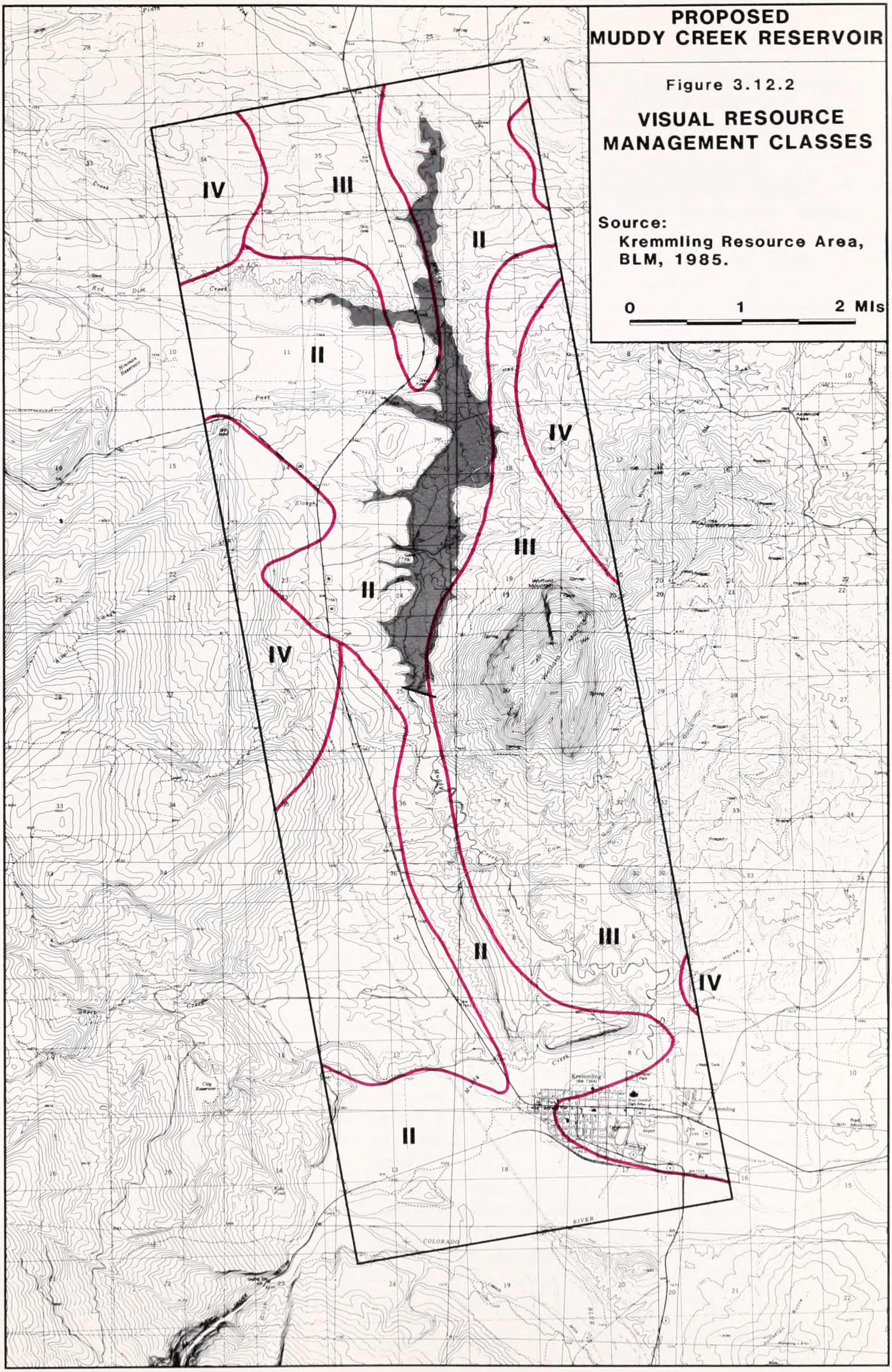
Approximately 85% of the affected environment is classified in the BLM's Visual Resource Management Class 2 (Fig. 3.12.2). The remaining 15% is within Management Class 3.

3.13. Recreation Conditions

3.13.1. Rock Creek. The area in immediate proximity to the reservoir site at Rock Creek receives a variety of recreation uses. A primitive camping area is located near the point where Shoe and Stocking Creek enters Rock Creek. A primitive camping area, with facilities limited to a single pit toilet is located near Shoe and Stocking Creek. The area attracts use both by visitors whose primary recreation objective is camping and by a considerable number of visitors who fish nearby sections of Rock Creek.

Visitation studies were conducted in the Rock Creek Area during August and September 1985 (Krannich and Keith, 1985). At the camping area, 95 percent of the 38 vehicles observed during this period had Colorado license plates. Only one of the 39 vehicles observed at the parking lot adjacent to the highway was licensed in another state. Use of both areas was concentrated during weekends when it was common to see one to four vehicles at each location. During weekdays, there were seldom any vehicles parked at either location.

Informal interviews were conducted with 32 individuals at the Shoe and Stocking camping area. Most of these individuals were non-locals, 81% resided in Colorado's east slope metropolitan areas and only one individual was from the local area. The primary reason for using the Rock Creek area was fishing, an activity which was reported by 91% of those contacted. About 55% were camping at the Shoe and Stocking area, with the remainder either camping


PROPOSED
MUDDY CREEK RESERVOIR
Figure 3.12.2
VISUAL RESOURCE
MANAGEMENT CLASSES
Source:
Kremmling Resource Area,
BLM, 1985.
0
1
2 MIs
IV
III
II
Kremmling
COLORADO
RIVER

elsewhere in the vicinity (23 percent) or engaging in day use of the area. Most were repeat visitors to Rock Creek (78 percent), with nearly 45 percent indicating that they visited the site three or more times annually.

Overall, these data suggest that significant levels of weekend recreation use occur at Rock Creek during the summer months, with most visitors being non-locals who are attracted by the fishing resource. Other uses such as hiking, motorcycling, and sightseeing are engaged in by smaller numbers of recreationists. The location of the historical stage stop building and Iron Spring in the Rock Creek basin attracts some additional visitation. During the winter the area receives limited recreation use, primarily by snowmobilers.

Another significant recreation use of the area is big game hunting in the fall, which according to the Forest Service Recreation Information Management System (RIMS) estimates comprises nearly one-fourth of all recreation visitation in the Yampa Ranger District. The Rock Creek area falls within the boundaries of Big Game Management Unit 15 as defined by the Colorado Division of Wildlife. In 1984 this unit attracted nearly 1,400 deer hunters during the rifle season, with a hunter success rate of 24 percent. Nearly 2,500 elk hunters used the area during the 1984 rifle season, with a success rate of 14% (Colorado Division of Wildlife, 1985).

The Rock Creek site is located within the Gore Pass Unit of the Routt National Forest's Yampa Ranger District. There are four developed campgrounds within this unit: Blacktail, Gore Pass, Lynx Pass, and Toponas Creek. As indicated in Table 3.13.1, these are all relatively small campgrounds which tend to have average occupancy rates ranging between 28 percent and 49 percent. In contrast, the other four developed campgrounds within the Yampa District, all located over 20 miles west of Rock Creek, exhibit significantly higher overall occupancy rates ranging between 57 percent and 65 percent. This is probably due in part to their location on or near small lakes, which tends to attract higher visitation levels than occurs at otherwise similar sites not adjacent to lakes. A review of campground compliance check records collected by the Yampa Ranger District shows that all of the campgrounds in the district tend to be full during the July 4 weekend and other major holiday periods. During other weekends the four campgrounds within the Gore Pass unit tend to have some excess capacity, while others in the district tend to be full or nearly full. Weekday use tends generally to be substantially below capacity at all of the district's campgrounds.

In addition to these developed camping areas, a wide variety of dispersed recreation uses occur on National Forest lands in the area surrounding Rock Creek, including hiking and backpacking, sightseeing, snowmobiling, off-road motorcycling, and firewood cutting. Forest Service personnel report a trend of increased use in recent years, with a majority of users coming from the Denver metropolitan area and other Front Range locations (Jaminet, 1986, pers. comm.).

In addition to the recreation resources in immediate proximity to the Rock Creek area, there are numerous recreation areas and opportunities elsewhere in Routt County. The ski resort at Steamboat Springs has become

Table 3.13.1. Campground characteristics, Yampa Ranger District

Campground	Number of campsites	1985 occupancy rate	1985 estimated visitor days
Blacktail Creek	8	39%	1,900
Gore Pass	12	36%	2,300
Lynx Pass	11	49%	2,900
Toponas Creek	8	28%	1,400
Horseshoe	7	60%	2,000
Cold Springs	5	65%	1,500
Stillwater	29	57%	6,600
Vaughn Lake	NA	NA	1,800

one of the largest destination resorts in Colorado. During the 1983-84 ski season, Steamboat attracted nearly 840,000 skiers (420,000 recreation visitor days), almost 10 percent of the statewide total for that year (Colorado Ski Country U.S.A., 1984). A recreation visitor day (RVD) is 12 hours engaged in a specific type of recreational activity which may be aggregated continuously, intermittently, or simultaneously by one or more persons.

Steamboat Lake State Park, located approximately 26 miles north of Steamboat Springs, provides a wide variety of recreation opportunities. The Colorado Division of Parks and Outdoor Recreation maintains over 250 campsites, several picnic areas, a marina, boat ramps, and other facilities at this park. Steamboat Lake attracts approximately 250,000 RVD annually (Colorado Division of Parks and Recreation, 1984a), including substantial use by fishermen and boaters. In recent years the lake has also attracted large numbers of windsurfers, even though local wind conditions are considered to be mediocre for such use (Costello, 1986; Stone, 1986).

Another popular location for fishing, sailing and windsurfing is Catamount Lake, a small (560 acres) private lake near Steamboat Springs. Managed as a private membership facility, this lake is used by 150 members. Despite the fact that wind conditions are not ideal, windsurfing use has increased rapidly during recent years, to the point that presently a majority of members are windsurfers. Most members are local residents who are attracted by the convenience of access to a nearby lake (Saunders, 1986).

3.13.2. Muddy Creek. The area which comprises the proposed Muddy Creek Reservoir site receives limited dispersed recreation uses on both private land and public lands administered by the BLM. Muddy Creek is not a quality fishery, and attracts very little fishing use. The creek provides some waterfowl hunting opportunities, although use levels are apparently quite low. Surrounding lands attract limited use by off-road motorcyclists, target shooters, and various other forms of dispersed recreation (USDI/BLM, 1984; Myers, 1986).

The most significant recreation use of lands immediately adjacent to the Muddy Creek site occurs during the big game hunting seasons. The location of the reservoir site itself is such that relatively few deer or elk are present prior to the winter months. However, the site is located within the boundaries of Big Game Management Unit 181 (Wolford Mountain) as identified by the Colorado Division of Wildlife. During the 1984 rifle season a total of 185 deer hunters used this unit, and encountered a 25% success rate. During the elk rifle season 844 hunters experienced a hunter success rate of 18% on this unit (Colorado Division of Wildlife, 1985).

The Muddy Creek site is located in a part of Colorado which contains a diversity of developed and undeveloped recreation areas and resources. During recent decades Grand County has experienced rapid growth as a result of ski area development, although most of that growth has occurred outside of the western section of the county in which Muddy Creek is located. There are four ski resorts in the eastern section of the county: Winter Park/MaryJane, Silver Creek, Ski Idlewild, and Berthoud Pass. The

largest of these is Winter Park/MaryJane, which during the 1983-84 ski season attracted 771,500 skiers, approximately 9 percent of the statewide total.

Also located in the eastern section of Grand County are Lake Granby, Shadow Mountain Lake, and Grand Lake, all approximately 40 miles east of the Muddy Creek area. The Arapahoe National Forest maintains a total of four campgrounds and 6 picnic areas on these lakes, as well as facilities to support fishing and boating activities. Another Forest Service recreation area in the eastern part of the county is Willow Creek Reservoir, located about 5 miles north of Granby.

Recreation areas closer to the Muddy Creek site include Williams Fork reservoir, located approximately 10 miles east of Kremmling. This 1,860-acre reservoir is operated by the Denver Water Department, with recreation use managed by the Colorado Division of Wildlife. The reservoir attracted approximately 43,475 annual visitors in 1984, with fishing the single most important recreation activity. This can be attributed to the low attractiveness of the sparse sagebrush vegetation that characterizes most of the surrounding area, the prohibition of swimming, windsurfing, and other body contact uses of the reservoir, the location of other more attractive reservoirs between this area and the major Front Range communities, and the absence of developed recreation facilities. Virtually all users are non-local residents, with an estimated 70 percent residing in the Denver metropolitan area (Colorado Division of Parks and Outdoor Recreation, 1984b).

Another reservoir near the Muddy Creek site is Green Mountain Reservoir, located in the northernmost section of Summit County. In recent years wind-surfing use at this reservoir has increased dramatically, with as many as 300-400 windsurfers present on busy weekends. The Arapaho National Forest maintains five campgrounds adjacent to the reservoir. Recreational use at Green Mountain was 164,000 RVDs in 1983, according to the Forest Service. Green Mountain attracts substantial fishing pressure, and moderate boating use which is usually curtailed in late summer when reservoir drawdowns make boat ramps unusable. Quality trout fishing is available in sections of the Blue River both upstream and downstream from the reservoir, with a section between the reservoir and the Colorado River listed as Gold Medal water by the Colorado Division of Wildlife.

In addition to these areas, substantial recreation use occurs on the section of the upper Colorado River which runs through the southern portion of Grand County. The stretch of the river between Pumphouse and State Bridge is encompassed by the Kremmling Resource Area section of the Upper Colorado River Special Recreation Management Area (SRMA). In the past 20 years use of this area by whitewater boaters has increased from an estimated 2,000 visitor days in 1965 to 31,305 in 1981 and 40,040 in 1985 (USDI/BLM, 1982; 1986). About 90 percent of the SRMA visitation within the Kremmling Resource Area is accounted for by the 39 commercial outfitters licensed to operate on this section of the river. Recreation activities in the Upper Colorado SRMA include whitewater floating (78 percent of use), fishing (14 percent of use), camping (6 percent of use), and hiking (2 percent of use) (USDI/BLM, 1982).

Although substantial increases in future river floating recreation have been projected (USDI/BLM, 1982), such uses would be seriously curtailed if currently appropriated water rights held by Denver and other East Slope users were to be fully utilized. Simulations of Colorado River flows (see Section 3.4.1.3 and Table A.3, Appendix A) indicate that if all appropriated uses were to occur, flows at Kremmling would be below 800 cfs during June, July, and August of most years. In general, flows below approximately 800 to 1,000 cfs are insufficient for river floating (Grant, 1986). Consequently, although historical flows have been sufficient to maintain the floating industry and associated recreation uses during the full summer season of most years, the simulated baseline flows indicate that even under existing conditions river floating activities will be significantly reduced from the levels recorded in recent years. Another area where floatboating is growing is the Blue River below Dillon Reservoir. More detail on this use can be found in the Green Mountain EIS (USDI/BR, 1985).

3.14. Cultural Resources

3.14.1. Regional Cultural History. This brief regional cultural history is summarized from Nickens (1986). The cultural historical sequence for the region encompassing the two proposed reservoir sites can be subdivided into two categories, prehistoric and historic. The general area appears to have been initially occupied in prehistoric times during the Late Paleo-Indian era (ca. 9500-5500 B.C.). Most of the data for this occupation in the region are scant, consisting of scattered finds of distinctive projectile points. The next cultural tradition, the Plains Archaic, is better represented in the region and has been subdivided into three periods including 1) the Early Plains Archaic (ca. 6000-3000 B.C.), the Middle Plains Archaic (ca. 3000-500 B.C.), and the Late Plains Archaic (ca. 1000 B.C.-500 A.D.). Following the Archaic occupation, the Late Prehistoric Period (ca. 500-1800 A.D.) is denoted by the presence of smaller side-notched projectile points and pottery. Late in this period and continuing into historic times was the aboriginal Protohistoric Period, peopled by the Ute, and the Arapaho, Cheyenne, Shoshone, Crow, Sioux and Blackfoot who occasionally ventured into the area from the Northwestern Plains. Protohistoric sites are characterized by the presence of trade artifacts such as beads and metal projectile points.

Historic Euro-American intrusions into the Middle Park and Gore Range area began with fur trappers in the first decades of the nineteenth century, followed by the gold rush and early mining years (ca. 1858-1870). Physical evidence of trappers and miners is unlikely to occur in the project areas. Settlement of the general region began in the 1860s, associated with the opening of transportation routes into Middle Park and over Gore Pass. In the following decades, ranching developed in Middle Park, along with the establishment of communities such as Kremmling (1881) near the Muddy Creek dam site. Development in the area included the stage route between Kremmling and the Yampa Valley, with a stage station at Rock Creek (built in the 1880s), and homesteading of the Rock Creek, Iron Spring, and Jolly Creek areas in the 1880s through the early 1900s. The National Forest, which includes the Rock Creek dam site, was established in 1905 as the Park Range Forest Reserve, renamed the Routt National Forest in 1908.

3.14.2. Rock Creek. Several previous cultural resource inventories have been conducted within or in the vicinity of the Rock Creek area. Those within the project area include studies associated with timber sales for the Routt National Forest (Farmer, 1979; Johnson, 1977; Klesert, 1981; Kurt, 1974; and Ward-Williams and Foster, n.d.), the West-East Natural Gas Pipeline (Arthur et al., 1979), and survey and monitoring projects for the Rock Creek Project (Alexander, 1985; Nickens and Associates, 1986; and Sullivan and Hartley, 1984a, 1984b). These inventories have recorded 23 cultural resource sites within approximately one mile of the proposed reservoir, including six historic sites, 16 prehistoric sites, and one isolated find. Among the historic sites is the Rock Creek Stage Station which was recorded in 1977 and placed on the National Register of Historic Places in 1982. Most of the prehistoric sites have unknown affiliation; however, artifacts of Archaic through Protohistoric age have been recorded. Aside from the stage station, only three of the sites have been evaluated for National Register of Historic Places eligibility, with each being recommended as not eligible. The remainder of the sites have not been evaluated.

3.14.3. Muddy Creek. Several cultural resource inventories have been conducted in the vicinity of the Muddy Creek study area. These include a Bureau of Land Management Class I overview (Schubert, 1981a) and Class II sample-oriented inventories (Fitting, 1978; Schubert, 1981b) and various other project specific inventories (Arthur, 1980; Arthur et al., 1979; Jones, 1979; Lischka and Black, 1979; and Shields, 1985). In addition, some drill holes at the dam site have also been inventoried (Sullivan, 1985) and a single historic site was recorded in 1976 by the BLM (Athearn, 1977). As a result of this past work, 11 cultural resource sites have been recorded within about a mile of the dam site area, ten of which are prehistoric. A majority of the prehistoric sites are of unknown age; however, one site yielded late Paleo-Indian and Archaic diagnostic materials. The single recorded historic site is an abandoned ranch. One other ranch, the Short Ranch homesteaded by the Hill family, is also within the proposed reservoir area. None of the recorded sites have been evaluated for eligibility for the National Register of Historic Places.

3.15. Paleontological Resources

3.15.1. Rock Creek. The granitic geology of the Rock Creek area suggests that no significant paleontological resources are found in the area.

3.15.2. Muddy Creek. The proposed dam on Muddy Creek would cover exposures of the Niobrara and Pierre Shale Formations that are known to contain fossils. Izett et al. (1971) discuss the fossils of the Pierre Formation in Middle Park, including some from localities in the vicinity of Muddy Creek, and the geologic map of Izett and Barclay (1973) shows those localities. Izett (1968) discusses the Niobrara Formation. The known fossil resources along Muddy Creek are not considered significant (Izett and Cobban, 1986).

A site visit was made to the area in July, 1986 (Kron 1986). Numerous fossils were found in the various layers of the two formations, but no significant fossils were found. The fossils were either so uncommon and poorly preserved, or occurred so commonly over a wide area outside the Muddy Creek area, that they had little scientific or educational value (Kron 1986).

The giant ammonite, Placenticeras neeki, a valuable paleontological find, exists in the Saron Springs sandstone layer of the Pierre Formation about 4-5 miles northeast of the proposed reservoir area. However, the Sharon Springs sandstone does not occur in the proposed reservoir area.

3.16. Social Conditions

3.16.1. Rock Creek (Routt County). During the 1970s, the population of Routt County increased rapidly, due in large part to the growth of the ski industry and other tourism-related activities. The county population grew from 6,733 in 1970 to 13,547 in 1980, an increase of over 100 percent. Although the rate of population increase has slowed considerably during the 1980s, the total number of residents grew to 14,635 by 1984, an increase of about 8 percent over the 1980 population.

Population growth in the county has been concentrated in and around Steamboat Springs, the county seat. In 1970, Steamboat Springs had only 2,340 residents, representing about 35 percent of the total county population. By 1983 the town's population had increased to an estimated 5,905, nearly 42 percent of the county total (based on estimates provided by the Colorado Division of Local Government, Demographic Section). Other areas of population concentration include the towns of Hayden (population 1,822 in 1983), Oak Creek (population 902 in 1983), and Yampa (population 468 in 1983). About 38 percent of the county population resides in rural areas and unincorporated villages.

Although several ranchers have grazing leases in the Rock Creek area, there are no homes in the immediate vicinity of the reservoir site. The settlements located nearest to the Rock Creek site are Yampa, which is about 18 miles from the site, and the unincorporated village of Toponas, which is about 10 miles from the site. These towns are very small and provide only limited services and public infrastructure. Steamboat Springs, which is about 48 miles northwest of Rock Creek, is the nearest location where a full array of public and private services can be obtained.

The sociocultural characteristics of Routt County reflect the influence of both historical development patterns and recent population growth and shifts in the area economy. Ranching and mining activities began in the area as early as the 1860s, and remained the primary bases of economic activity and population growth in the county until the 1970s. During the past two decades growth related to recreation industries in and around Steamboat Springs has resulted in the appearance of a mobile and relatively cosmopolitan population, with relatively non-traditional and diverse lifestyles and values. However, these developments have primarily affected

the Steamboat Springs community. Throughout the rest of the county, mining (especially for coal) has remained a major source of employment, and agriculture and forest product industries also continue to be important (Browne et al., 1982). In these more rural areas of the county, traditional social structures characterized by informality and an emphasis on self-reliance and community independence have persisted (USDA/FS, 1983). However, recent and ongoing economic shifts and changes in the characteristics of the area population are gradually undermining the stability of traditional rural ways of life.

Although growth remains concentrated in the Steamboat Springs vicinity, continued expansion of tourism activities has influenced areas throughout the county. In addition, during the past few years the gradual decline of the ranching industry and a downturn in coal mining activity have created considerable economic uncertanity for many residents of this part of Colorado, particularly in communities which are less heavily influenced by tourism such as the Oak Creek and Yampa areas (USDI/BLM, 1986). Comments received during the EIS scoping process and informal comments provided by a number of local informants indicate that at present there is considerable support among local leaders and among residents of the more rural areas of the county for development which could create new job opportunities and economic activity. This observation is consistent with findings reported by numerous researchers who have documented high levels of public and leadership support for economic development in most rural areas (Gold, 1985; Krannich and Humphrey, 1983; Little, 1976).

3.16.2. Muddy Creek (Grand County). Grand County has exhibited sustained, moderate growth in recent decades. Between 1970 and 1980 the countywide population grew from 4,236 to 7,564, an increase of over 78 percent. During the 1980s the number of residents in the county has continued to expand, reaching an estimated 9,210 by 1984, an increase of about 22 percent in four years. Most of this growth can be attributed to in-migration associated with the expansion of recreation and tourism activities in the county.

Grand County is naturally divided into eastern and western sections which are separated by Byers Canyon (USDI/BLM, 1984). During the 1970s and 1980s most of the population increase in the county has been concentrated in the eastern section, reflecting the effects of ski resort expansions and other tourism-related growth. Population centers in this part of the county include the towns of Fraser (population 597 in 1983), Granby (population 1,154 in 1983), Grand Lake (population 476 in 1983), Winter Park (population 610 in 1983), and Hot Sulphur Springs, the county seat (population 453 in 1983).

The only incorporated town in the western portion of Grand county is Kremmling, which had an estimated population of 1,378 in 1983. Located immediately downstream from the Muddy Creek reservoir site, Kremmling is a service center for the surrounding rural sections of western Grand County, and as such provides a variety of public and private services, including the area's only hospital (USDI/BLM, 1984; Myers, 1986). At the Muddy Creek reservoir site there are two ranching homesteads located immediately

adjacent to the creek. At present both are used to provide temporary housing of ranch hands and as seasonal operations bases for large ranches headquartered elsewhere.

Growth in this part of the county has been uneven in recent years, due largely to continued economic reliance on presently depressed and often volitile markets for agricultural, mining, and lumber products (Leigh, Scott and Cleary/Fox Fire Planning, 1985). Although substantial growth occurred during the 1970s, recent cutbacks of operations at the Amax Henderson Mill near Kremmling and the Lousiana-Pacific chip board plant in Kremmling have contributed to a virtual no-growth situation in the western part of the county during the past two or three years. In Kremmling, some population decline has occurred as a result of reduced employment opportunities, and numerous homes have become available for sale or rent (Myers, 1986).

The sociocultural characteristics of Grand County reflect both the east-west division of the county and the different development experiences of the two sections. In the eastern section of the county, traditional social structures have for the most part been eliminated as a result of the growth of tourism-related activities and related population changes. The presence of a highly transient and generally cosmopolitan population has contributed to an increased reliance on formal rather than informal mechanisms for attending to individual and community needs. As is usually the case under such conditions, overall social cohesion appears to be limited (USDI/BLM, 1984).

In contrast, the western part of the county is still characterized by the persistence of traditional rural social structures associated with the ranching heritage of the area. Social status and political influence tend to be concentrated among members of established ranching families. The local value system emphasizes informality, self-sufficiency, and cohesive integration among established community members (USDI/BLM, 1984).

In the Kremmling area, the persistence of relatively traditional social structures is challenged by the expansion of tourism-related urban development patterns in nearby parts of Grand and Summit counties, and by the instability of traditional economic activities. Although some "old-timer" residents feel threatened by the decline of the ranching community and the potential for new development, most local residents and community leaders appear highly supportive of new development and growth opportunities, (DeWitt, 1986; Jones, 1986).

3.17. Economic Environment

3.17.1. General. This assessment focuses on the economic conditions in Grand and Routt counties, even though the water from the proposed Rock Creek or Muddy Creek reservoirs will be used primarily outside of both counties (see Section 2.4.7) rather than directly in production activities such as agriculture or power production in either county. Both Grand and Routt counties have relatively diversified economies, including mining,

agriculture, and some manufacturing and tourism that provide demand for the region's products and services. In both counties, tourism and recreation accounts directly for a substantial portion of sales, employment and income. This tourist activity is dominated in both counties by the ski industry. Because the proposed reservoirs lie in different counties, the counties will be examined individually. Table 3.17.1 indicates the general economic trends for each county from 1970 to 1984. Table 3.17.2 indicates the distribution of total personal income among the various sectors of the economy in each county.

3.17.2. Routt County. The skiing industry, directly or indirectly, accounted for about 45 percent of employment and personal income, and about 60 percent of retail sales in Routt County for 1980 (Colorado Ski Country USA, 1984). These estimates may be somewhat overstated, because all visitation to ski areas by summer visitors are classified as ski-industry related. Retail sales in 1981-82 did, however, reflect the "poor" snow years when the ski industry was depressed economically, which refects the overall importance of the ski industry to the county.

The other major production industry in Routt County is coal mining, which provides coal for the power plants at Craig and Hayden. While the Craig power generation plant is not in Routt County, some Routt County residents commute to this plant. Mining activity accounted directly for about 15 percent of employment and income in the county in 1980. However, during the past 2 to 4 years, the coal market has declined substantially, so that mining income has fallen some 5 to 15 percent per year. This has increased the importance of tourism in the economic structure of the economy since 1980.

Water-based recreation is important in the county. An estimated 250,000 visitor days occurred on Steamboat Lake during 1983. An additional 10,000 visitor days were associated with recreation visits on Stillwater and Vaughn Lakes in Routt County. Fishing expenditures were estimated by McKean and Nobe (1983) as $300 per capita for residents and $482 for non-residents in Colorado (1981 prices). Data from the State of Colorado indicate that each resident fisherman takes an average of 10 trips per year with about 1.2 visitor-days per trip. The resultant expenditure per trip is $30 or about $25 per visitor day. The problems with these data are the failure to distinguish fishing expenditures from other costs of the trip associated with other impacts and the failure to identify the point of expenditure. McKean and Nobe (1983) recognize these problems, but are not able to adjust the data. In other studies of similar kinds of recreation experiences in Utah (Keith and Farnsworth 1984), the average expenditure ranged from $40 to $140 per trip. This suggests that $6 to $8 million in retail sales are directly associated with reservoir-based recreation in the county. Stream fishing, although unquantifiable, is likely significant along the Yampa River and in creeks such as Rock Creek. Pass through tourism is also probably a significant factor in the county's economy, although its impact is unknown, and it is included to some extent in the fishing, hunting and skiing industry impact calculations.

Table 3.17.1 Selected Indicators of County Growth and Economic Activity, 1970–1983.

	1970	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Grand County											
Population (12/31	4493	6473	6534	6736	7056	7386	7698	8053	8465	8779	9640
Percent Change	---	6.27*	0.94	3.08	4.75	4.68	4.22	4.62	5.12	3.71	9.81
Retail Sales (000)	43485	57092	64058	67807	76290	88862	91169	90272	90247	98032	109843
Percent Change	---	0.82*	12.20	5.85	12.51	16.48	2.60	-0.98	-0.03	8.63	12.05
Total Assessed Value (000)	42985	98861	130829	144679	141278	134261	142742	155403	144971	154067	---
Percent Change	---	4.47*	32.34	10.59	-2.35	-4.97	6.32	8.87	-6.71	6.27	
Employment 1/	2104	3817	4497	4236	4388	4873	5450	5843	5689	6708	---
Percent Change	---	10.44*	17.82	-5.80	3.59	11.05	11.84	7.21	-2.64	17.91	
Employment 2/	1169	2546	2804	2653	2928	3255	3650	4010	3937	4005	---
Percent Change	---	13.85*	10.13	-5.39	10.37	11.17	12.14	9.86	-1.82	1.73	
Total Personal Income (000) 2/	26284	56751	64208	62239	74592	80321	87480	91100	92683	97111	---
Percent Change	---	13.69*	13.14	-3.07	19.85	7.68	8.91	4.14	1.74	4.78	
Routt County											
Population	7014	9804	10384	11226	12386	13261	13562	13763	14042	14385	14884
Percent Change	---	5.74*	5.91	8.11	10.33	7.07	2.27	1.48	2.03	2.44	3.47
Retail Sales (000)	43978	98745	107601	110061	144054	196179	200685	202559	189555	186668	199786
Percent Change	---	14.43*	8.97	2.29	30.89	36.18	2.30	0.93	-6.42	-1.52	7.03
Total Assessed Value (000)	65373	127452	167767	172511	189674	182877	187599	202175	194792	207146	---
Percent Change	---	11.77*	31.63	2.83	9.95	-3.58	2.58	7.77	-3.65	6.34	
Employment 1/	2866	6022	7169	7454	8748	10680	11694	11544	11414	7451	7835
Percent Change	---	13.17*	19.05	3.98	17.36	22.09	9.49	-1.28	-1.13	-34.72	5.15
Employment 2/	1943	3821	4350	4611	5581	6734	7365	7294	7317	7220	
Percent Change	---	11.93*	13.84	6.00	21.04	20.66	9.37	-0.96	0.32	-1.33	
Total Personal Income (000)	49742	94055	107534	118528	143410	171080	183310	185769	187416	185233	
Percent Change	---	11.20	14.33	10.22	20.99	19.29	7.15	1.34	0.89	-1.16	

(Source: Colorado Department of Local Affairs, County Profile Data Files and Bureau of Economic Analysis

All Dollar Values are in 1983 Dollars.

* Average annual growth from 1970 to 1975.
1/ Taken from Co. Dept. of Local Affairs: includes part-time and multiple job holders, and self-employed persons.
2/ Taken from BEA data: full time equivalent wage-earning jobs.

Table 3.17.2
Distribution of Personal Income by Percent (1980)

Sector	Grand County 1975	Grand County 1983	Routt County 1975	Routt County 1983
Agriculture	0.09	2.15	4.25	2.41
Agricultural Service	0.03	n/a	0.37	0.42
Mining	1.83	n/a	15.42	15.54
Construction	34.99	0.08	6.37	8.89
Manufacturing	4.53	2.09	1.18	0.87
Transport	5.33	4.64	4.71	9.06
Wholesale Trade	0.60	0.54	0.97	0.97
Retail Trade	11.63	18.89	10.04	9.84
FIRE 1/	2.33	3.89	3.77	4.75
Services	14.49	28.15	14.72	17.68
Government	17.64	21.61	22.17	16.84
Other 2/	6.51	17.96	16.03	12.73

1/ Finance, insurance, and real estate.

2/ This category is composed of various transfer payments such as social security, dividends, interest, etc.

Source: Colorado Ski Country USA (1982 a, b, c)

Hunting also plays a significant part in the local economies, particularly outside of Steamboat Springs. It has been estimated that big game hunters spend from approximately \$140 (resident) to \$460 (non-resident) per capita for elk and deer hunting in the area (McKean and Nobe, 1984). It is assumed that the average hunter takes 1.1 trips per year and that the average trip is composed of two hunter-days. Little information is available from the State of Colorado relative to the assumptions. These data were taken from unpublished studies in the State of Utah, thus, there are approximately \$60 per hunter-day for residents and \$210 per hunter-day for non-residents spent by hunters. An estimated \$27 million was spent by resident and \$24.4 million by nonresident hunters of big and small game in the State of Colorado in 1981. Of this, about 14 percent would have been spent in the Grand, Routt, Jackson, Summit, Eagle and Pitkin County region. Using a multiplier of about 1.6 to 2.0 for retail sectors in these counties, the total direct and indirect effect would have been approximately \$12.8 million. These effects cannot be separated by county with the data given in the McKean and Nobe (1984) report. However, using data from the 1983

hunter harvest and the calculated expenditure per hunter-day, elk and deer hunters spent approximately \$2.5 to 3.5 million in Routt County. Using the 1.6 to 2.0 multiplier, the total retail sales affected would be about \$5 million (direct and indirect).

Governmental employment is also a significant factor in the local economy, although the growth of the ski industry has overshadowed growth in governmental employment to some degree, so that the proportion of income from governmental activity declined slightly from 1975 to 1980 (Table 3.17.2). With the reduction in mining activity, the governmental sector has likely increased in relative importance in the past two to four years.

3.17.3. Grand County. Grand County's economic and demographic growth has been relatively steady since 1970, although some years exhibited significant deviations from that trend. For example, a boom in construction associated with an expanding ski industry in the Winter Park area in the mid-1970's was responsible for the large portion of income in the construction sector. From 1978 onward, however, construction income and employment have remained substantially below the 1976-77 period. The increasing portion of retail trade and services sectors within the county are also the result of the expanding ski industry in the Frazier River Basin. Colorado Ski Country USA (1984) estimated that approximately 54 per cent of employment and personal income, and 62 percent of retail sales, in Grand County are directly or indirectly related to the ski industry. These estimates may be somewhat overstated, as noted for Routt County, yet there is little doubt that close to half of the economic activity in Grand County is dependent upon skiing.

Manufacturing has played an important local role in some towns, contributing approximately 5 percent of the personal income for the county (Table 3.17.2). Louisiana Pacific's wood products plant in Kremmling accounted for the major manufacturing employment in the western region of the county. Since 1980, however, the decline in the lumber industry has resulted in declining employment and income in the area. As pointed out previously, the Kremmling area (western Grand County) has probably not been greatly impacted by the growing ski industry.

Water-based recreation is also important in Grand County. An estimated 20,000 nonresidents and 460,000 residents participated in fishing activity in the six-county region of Grand, Routt, Jackson, Summit, Eagle and Pitkin. There are no data by which to estimate fishing activity in Grand County alone, but given the blue ribbon streams and some reservoirs (an estimated 40,000 visitors to Williams Fork Reservoir in 1984), it is likely that from \$1 to \$4 million are spent on fishing in Grand County annually, with a multiplier of about 1.6 to 1.8 for retail expenditures (Colorado Division of Parks and Outdoor Recreation, 1984). There are significant amounts of river floating activity in the area, amounting to approximately 30,000 to 40,000 user days in 1976 and 40,000 to 50,000 user days in 1980. These activities produced less than \$2 million in total direct and indirect expenditures. That value has probably risen substantially over the past five years; still, this is a very small part of total retail expenditures for the county (Tierney, 1980).

Other recreation activities of importance in the county are related to big game hunting. As discussed for Routt County, hunters spend from $140 for residents to $460 for non-residents per capita for deer and elk (McKean and Nobe, 1984) which result in approximately $60-$210 per hunter-day. Using typical expenditures and hunter days for the 1984 season, the total elk and deer related expenditures for Grand County would have been approximately $1-2 million direct, and approximately $2-3 million direct and indirect. These are gross retail sales values, and should be compared to total retail sales for the county ($109 million) to determine the relative importance of hunting to the county. Of course, certain towns, such as Kremmling, are likely to be much more dependent on hunting expenditures for outside income than the county as a whole.

Pass-through camping and tourism along U.S. Highway 40, a major interstate transportation corridor, are likely of significance to the county. However, a significant portion of this activity is probably aptured in the estimates of both water and ski-related recreation activity.

Government employment and payroll has played an increasingly significant role in Grand County over the past decade. The growth in government employment is not atypical of the land management agencies in the Western United States.

3.18. Transportation

3.18.1. Rock Creek. State Highway 134, which crosses Gore Pass between Kremmling and Toponas (Fig. 2.4.1), is sited at the upper end of the proposed Rock Creek Reservoir. At present Highway 134 is moderately used. See Section 3.12.1 (Visual Resources) for additional discussion.

3.18.2. Muddy Creek. U. S. Highway 40 traverses the Muddy Creek drainage adjacent to the proposed Muddy Creek Reservoir (Fig. 2.5.1). Highway 40 crosses Rabbit Ears Pass between Kremmling and Steamboat Springs and is moderately to heavily used. See Section 3.12.2 (Visual Resources) for additional discussion.

4.0. ENVIRONMENTAL CONSEQUENCES

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4.0. ENVIRONMENTAL CONSEQUENCES

4.1. Introduction

4.1.1. General. In this chapter the environmental consequences of the alternatives considered in detail are analyzed and summarized. The environmental consequences are evaluated first for the no action alternative, and then for the proposed action--the construction of a dam and reservoir on Rock Creek. Finally, the alternative construction of a dam and reservoir on Muddy Creek is discussed. While the no-action alternative is discussed in general, nondiscipline-specific terms, the Rock Creek and Muddy Creek alternatives are evaluated discipline by discipline. Within each discipline-specific section, the discussion generally follows the sequence of (1) anticipated impacts, (2) mitigation of those impacts, and (3) a summary of unavoidable adverse impacts.

As discussed in Sections 2.4.7 and 2.5.7, the proposed operations of both Rock Creek Reservoir and Muddy Creek Reservoir involve a Metro Denver Lease (interim or short-term) scenario and a West Slope (long-term) scenario. The basis for the Metro Denver Lease operational scenario was established under the Denver Water Board-River District Agreement of December 1986 (see Section 1.3.6). The West Slope operational scenario involves projecting population growth and other water demands well into the future, making it difficult to accurately forecast the quantity and timing of these future demands. Consequently, the impacts evaluation of this chapter is based on the Metro Denver Lease (interim) water demand scenario for the primary damsite. Any differences in impacts at an alternate damsite are also discussed. Mitigation measures and their effectiveness based on the best available information are discussed for each alternative in Chapter 5. An ongoing monitoring program is in place to evaluate the effectiveness of proposed mitigation measures. A more detailed mitigation plan will be incorporated into the final EIS.

A summary of the unavoidable adverse environmental impacts disclosed by the analysis for each discipline is presented with each discipline. Cumulative impacts are discussed in Section 4.5.

4.1.2. Hydrologic Data. The existing environment (pre-project) hydrologic data presented in Section 3.4 and the post-project hydrologic data in Sections 4.3.3 and 4.4.3 are used as a basis for analysis by most disciplines. The volume of data developed precludes presenting more than summary tables and figures for the Metro Denver Lease operational scenario in this chapter. Two separate technical reports on hydrology have been prepared as reference documents for this EIS (Resource Consultants, Inc., 1987 a and e). Copies of these technical reports containing complete spread sheets, tables, and figures for both the Metro Denver Lease and West Slope scenarios are available on request from the U.S. Forest Service, Routt National Forest.

Although some gaging stations in the basins of concern have longer periods of record, for assessment of impacts the period water year 1962

through water year 1982 was selected to provide a consistent basis for analysis. Selected annual summary tables and figures for the Metro Denver Lease scenario are presented in appropriate sections of this chapter. Monthly summary hydrologic data for both the Metro Denver Lease and West Slope scenarios are provided in Appendix A. The evaluation of impacts in this chapter is based only on the Metro Denver Lease scenario.

4.2. No-Action Alternative

The no-action alternative assumes that a permit for construction of a dam and reservoir would not be issued for any site on either Rock Creek or Muddy Creek. Management of the use of the resources of the region would be based on plans, regulations, and policies promulgated by Federal, State, and local agencies. Consequently, under this alternative changes to the existing environment of the region would continue as in the recent past. A no-action condition would terminate the involvement of the Forest Service and Bureau of Land Management in this application for a Special Use Permit; but the Colorado River Water Conservation District and other West Slope and East Slope entities could not terminate efforts to find a means of adequately mitigating the potential harm to present and prospective water users within the Colorado River basin in Colorado as a result of the Windy Gap Project (see Section 1.3.1).

Construction of the Windy Gap Project was completed in June 1985 and the project is now in operation. Authorization for that project was contingent upon development of a plan to mitigate potential impacts to water users on the Colorado West Slope. Development of that mitigation plan required a series of complex legal and institutional actions. Under the no-action condition the River District would be required to initiate a variety of legal and institutional proceedings related to the adjudication and negotiations outlined in Chapter 1. These proceedings would involve additional adjudication under the Azure-Windy Gap Supplement Agreement of March 29, 1985 (Section 1.3.5). Any attempt to predict the outcome of these proceedings and assess the environmental impacts that might result would, at this time, be purely speculative.

It is apparent, however, from a review of alternatives considered but eliminated from further consideration (see Section 2.2) that the options available to provide mitigation for the Windy Gap Project are limited. Alternative structural and non-structural solutions potentially available to the River District cannot meet the screening criteria of project water yield, reasonable project cost, and project location.

Given the difficulty of developing alternative solutions it is certain that a no-action condition would defer the resolution of a number of significant problems for both West Slope and Metro Denver water users (see Section 4.3.3.1). Over the short term, the Denver Water Board's ability to meet a Green Mountain fill deficit or to use a Williams Fork to Dillon exchange could be limited. For West Slope water users the ability to use the full potential of Green Mountain Reservoir water through contract sales could be curtailed. If a no-action condition were to continue indefinitely, municipal and industrial use of water above Shoshone could be impacted and

recreational development, particularly in relation to the West Slope ski industry, could be limited. Site-specific and cumulative environmental impacts associated with the two dam and reservoir alternatives as discussed in the remainder of this chapter would not occur.

4.3. Rock Creek Dam and Reservoir

4.3.1. Geology

4.3.1.1. Anticipated Impacts. The potential for valuable, locatable or leasable mineral deposits on the Routt National Forest is low and none have been identified in the proposed Rock Creek Reservoir area. Some salable deposits of construction aggregates have been identified and would be utilized in the construction of Rock Creek dam. The quantities used would be relatively small and deposits are located in the proposed reservoir basin. Consequently, impacts on geology and minerals would be insignificant.

The seismic study summarized in Section 3.2.3 concluded that faults in the Rock Creek basin are either non-seismogenic or there is no conclusive evidence of seismogenic movements. Other seismically induced hazards including surface faulting, liquefaction, reservoir seiche, and induced seismicity are believed low to virtually non-existent in the Rock Creek project area. Thus, no impacts related to seismicity are likely.

4.3.1.2. Mitigation. No mitigation is required in relation to geology, minerals, or seismicity.

4.3.1.3. Unavoidable Adverse Impacts. There are no unavoidable adverse impacts in relation to geology, minerals, or seismicity.

4.3.2. Soils

4.3.2.1. Anticipated Impacts. Impacts associated with the construction and operation of this alternative include: (1) the loss of soil resource utility due to inundation; (2) disturbance and erosion of soil along the reservoir water line due to water level fluctuation; and (3) disturbance and increased erosion of soils at construction sites including the dam, roads, powerline, campground, reservoir overlook, and picnic ground.

Inundation. Construction and operation of the Dam Site B alternative would inundate a total of 1070 acres of land at the normal maximum reservoir operating level. Table 4.3.2.1 summarizes the area of each soil association in the study area that would be inundated by the reservoir.

Table 4.3.2.1. Summary of acres of soil associations inundated and crossed by the shoreline of the proposed Rock Creek reservoir.

Soil Grouping	Study Area (acres)	Inundation			Shoreline	
		Area (acres)	Percent of Study Area	Percent of Inundation	Length (mile)	Percent of Shoreline
Soils on steep upper slopes covered with mountain big sagebrush	2,690	270	14	25	8.6	45
Soils on gentle lower slopes covered with mountain big sagebrush and silver sagebrush	1,283	305	7	29	5.0	26
Soils on wet valley bottoms	1,739	477	9	44	3.5	18
Soils in forested areas	13,464	18	70	2	2.1	11
Totals	19,176	1,070	100	100	19.2	100

The usefulness of these soils as a plant growth medium would be lost due to inundation as long as the reservoir was in operation. Sediment transported to the reservoir by streams and overland flow would be deposited on the surface of the inundated land covering the naturally occurring soils. Because all of the soils in the study area are common and widespread, loss of these soils due to inundation would not result in significant impact.

At normal maximum operating level, the reservoir would have approximately 19.2 miles of shoreline. Table 4.3.2.1 summarizes the distance that the shoreline would cross each soil association. The soils along the shoreline would be subjected to water level fluctuation, waves and currents that would erode soil material at or just below the water line and deposit the materials on the inundated shore below the lowest level of the wave energy. Consequently, the combined erosion and deposition of soil materials would cause small wave cut/deposited terraces to form at the elevation of any water level stabilization. The materials eroded and deposited would range from silts and clays to sands, gravels and cobbles, depending on the soil at a particular site along the shore line. All vegetation inundated would be killed, and hence, little if any protection to the shoreline would be provided by vegetation. Due to the continually fluctuating water level, vegetation would not pioneer the bare shoreline because the area would not offer a stable environment for the establishment of vegetation.

The width of the water level fluctuation zone along the shoreline would be inversely proportional to the slope gradient. The steeper the shoreline slope, the narrower the zone of shoreline fluctuation and therefore, the less the magnitude of impact caused by wave action. Table 4.3.2.2 indicates the width of the fluctuation zone for an average steep shoreline slope near the dam site (55 percent), average moderate shoreline slope near the site of the proposed campground (25 percent), and an average slope at the upper end of the reservoir (1.0 percent).

The character of the shoreline for the most part would be determined by the type of soil; its stability and texture, depth and slope. Consequently, the suitability of the shoreline to recreation activities such as fishing, swimming, and boating would vary according to these conditions. The following criteria define broad recreation suitability classes:

<u>Highly suited</u>: Shorelines composed primarily of sand with some gravel and minor amounts of silt and clay that are firm and stable under the weight of a human.

<u>Moderately suited</u>: Shorelines composed primarily of silts and sands with some gravel and clay that are somewhat firm and stable under the weight of a human. There is a tendency of the soil material to cling to feet.

<u>Poorly suited</u>: Shorelines composed primarily of silts and clays with minor amounts of sand and gravel that are soft and unstable under the weight of a human. Feet easily sink and materials cling easily to feet. Shorelines composed of rock outcroppings with very steep slope gradients.

Table 4.3.2.2
Horizontal Shoreline Fluctuations, in feet,
for Three Assumed Slope Gradients and
Two Vertical Water Level Fluctuations

Shoreline slope 1/ (percent)	Normal fluctuation 10 feet	Drought year fluctuation 80 feet
55	18	146
25	40	320
1	1,000	8,000

1/ 55 percent slope near dam site
25 percent slope near the site of the proposed campground
1 percent near upper end of reservoir

The shoreline soils on steep upper slopes covered with mountain big sagebrush (8.6 miles) would consist of sand and gravel with some cobbles. Approximately 2 percent of the total shoreline would consist of rock outcropping. The soil and subsoil materials of this mapping unit would provide a stable shoreline with minor amounts of silt and clay. Except for outcroppings with steep slopes, shorelines occurring on these soils would be highly suited to recreation activities.

The shoreline soils on lower slopes covered by mountain big sagebrush and silver sagebrush (5.0 miles) would consist primarily of silts with lesser amounts of sand, gravel, and cobbles. In areas near or adjacent to drainages, transported sediments would be deposited forming small deltas. Both materials would be easily eroded by waves and currents resulting in constant readjustment of the shoreline with water level fluctuations. The shoreline would be moderately stable; however, some areas may be subjected to slumping due to slope undercutting and an increase in pore water pressure. Shorelines occurring on these soils would be moderately suited to recreation activities.

Shorelines occurring on forested soils (2.1 miles) would closely resemble those previously described for soils on steep upper slopes covered with mountain big sagebrush, and would be highly suited to recreation activities.

Shoreline soils in wet valley bottoms (3.5 miles) would be sites of sediment deposition where streams flow into the reservoir. Consequently these areas would likely be the sites of delta formation consisting of silts and clays. Stream channels inundated at the normal maximum reservoir operating level would be incised by the streams during low reservoir levels due to the change in base level. These areas would be mud flats at low reservoir level stages. The shoreline would be subjected to erosion and bank slumping where steeper slopes occur in this unit. Shorelines occurring on these soils would be poorly suited to recreation activities.

Compilation of these estimated shoreline characters indicates that approximately 10.7 miles or 56 percent of the shoreline would be highly suited to recreation activities. Approximately 5.0 miles or 26 percent of the shoreline would be moderately suited to recreation activities, and 3.5 miles or 18 percent of the shoreline would be poorly suited to recreation activities.

There is a potential that concentration of cattle at certain points along the shoreline of the reservoir could cause increased erosion and instability of the soils as well as a reduction of suitability for recreation. However, the size of these concentration areas would be relatively small relative to the total area of shoreline, and thus, would not be considered significant unless located within a high-use recreation area.

Implementation of Dam Site A would result in inundation of approximately 65 fewer acres than Site B. Of these 65 acres, 14 acres would be soils on wet valley bottoms, 37 acres would be soils on steep upper slopes covered by mountain big sagebrush, and 9 acres would be forested soils. Under this alternative there would be approxiamtely 1.5 miles less shoreline, all on soils on steep slopes covered with mountain big sagebrush. Aside from the smaller area of inundation and shorter length of shoreline, the impacts discussed for Dam Site B would be very similar to those resulting from Dam Site A.

<u>Facilities Construction</u>. Construction of the dam, dam access road, campground, picnic ground, reservoir overlook, and relocation of the transmission line and Highway 134 would cover, disturb, and destroy existing soil resources. In cases where construction involved covering the soil or removing soil without salvage, soil resources would be lost. Where construction involved the disturbance of soil left in place, the soil would be subjected to greater overland flow, erosion, and offsite sedimentation. Generally, the cumulative area disturbed would be relatively small, thus it is doubtful that a significant increase in erosion and offsite sedimentation would occur overall. However, where construction occurs in close proximity to streams, the potential for significant increase in sediment loading is greater. The areas of soil disturbance that would result from facilities construction are summarized in Table 4.3.2.3.

Construction of Dam Site B would result in less soil disturbance than Dam Site A. Standard operating procedures, including site specifically designed and implemented runoff and erosion control, would reduce soil loss and offsite sedimentation to acceptable levels.

The campground would be located on approximately 25 acres of forested soils and 15 acres of soils on lower slopes covered with mountain big sagebrush and silver sagebrush. A minor amount of increased surface runoff, erosion, and offsite sedimentation would occur in the short term as a result of the disturbance of approximately 3.0 acres associated with the campground construction as shown in Table 4.3.2.3. The campground site suitability analysis (Johnson and Grah, 1986), as well as data included in Table 3.3.2 (Section 3.3.1), indicate that the soils at this site would be suitable for this type of development with few if any resultant impacts.

Table 4.3.2.3. Summary of acres of soil units that would be destroyed or disturbed due to facilities construction and inundation at the Rock Creek Site.

Component	Steep Upper Slopes Covered With Sagebrush	Gentle Lower Slopes Covered With Sagebrush	Coniferous Forest	Wet Valley Bottoms	Total
Facilities					
Access road[1]	2.0	9.0	7.5	6.8	25.3
Highway[2]	4.4	1.0	0.0	1.1	6.5
Powerline[3]	0.5	0.5	2.0	0.1	3.1
Campground[4]	1.0	0.0	2.0	0.0	3.0
Day use facilities[5]	1.0	0.0	1.5	0.0	2.5
Overlook[6]	0.0	1.0	0.0	0.0	1.0
Subtotal	8.9	11.5	13.0	8.0	41.4
Percent of total in study area	0.3%	0.9%	>0.1%	0.5%	0.2
Dam Site B					
Construction[7]	3.0	0.0	0.0	0.5	3.5
Inundation	270.0	305.0	18.0	477.0	1070.0
TOTAL (including subtotal above)	281.9	316.5	31.0	485.5	1114.9
Percent of Total	25%	28%	3%	44%	100%

1- assuming a 40 foot wide right-of-way along a 5.2 mile length.
2- assuming a 75 foot wide right-of-way along 3,210 feet.
3- assuming a 50 foot wide right-of-way in forest and minor amounts in sagebrush complex and wetland along its 3.6 mile length.
4,5,6- assuming a minimal hypothetical amount of disturbance.
7- based on location of dam site and topography.

The picnic ground would be located on approximately 5 acres of forested soils and 1 acre of soils on steep upper slopes covered with mountain big sagebrush. The boat ramp and parking lot would be located on approximately 14 acres of soils on steep upper slopes covered with mountain big sagebrush. Impacts resulting from the construction and operation of this site would be minor and similar to those described above for the campground. A total of approximately 2.5 acres would be disturbed. The site suitability analysis indicated that the soils of this site would generally be suitable for this type of development.

4.3.2.2. Mitigation. A successfully implemented site-specific plan for runoff, erosion, and sedimentation control, as well as a revegetation plan, would greatly reduce increased erosion, soil loss, and offsite sedimentation due to project construction. Site-specific plans would be developed for the Rock Creek site. The general points and procedures of such plans are discussed in Water Quality (Section 4.3.3.5). A detailed soil and water monitoring and mitigation plan applicable to either site is included at Appendix C. Should cattle concentration occur along the shoreline within or near recreation sites, the areas could be fenced or mineral and salt sites could be established away from the shoreline to preclude cattle concentration near recreation sites.

4.3.2.3. Unavoidable Adverse Impacts. There are no unavoidable adverse impacts on soil resources.

4.3.3. Surface-Water Resources

4.3.3.1. Projected Water Use for Rock Creek Reservoir. The proposed uses of water take the form of two demand scenarios: a short-term (25-year) lease of a portion (90 percent) of the yield of the reservoir to the Denver Water Board for incorporation into their system of augmentation reservoirs (Metro Denver Lease), and an ultimate long-term use of the water for the benefit of western Colorado in general, and the Upper Main Stem of the Colorado, in particular (West Slope scenario). While data on both scenarios are presented in Appendix A and the hydrology technical report, the firm demands of the Denver Metro Lease scenario are used as a basis for impacts assessment in this chapter (see Section 1.3.6). The West Slope scenario involves projecting water demands well into the future (25 years and beyond), making it difficult to accurately forecast the quantity and timing of these demands. A review of Appendix A and the hydrology technical report (Resource Consultants, Inc., 1987a) indicates that, in general, the Metro Denver Lease places greater hydrologic demands on Rock Creek, Muddy Creek, and the Colorado River system than the current projections of West Slope demand.

The amount and distribution of the water required by Denver for the Metro Denver Lease was estimated using the USBR's Green Mountain Simulation Model (USDI/BR, 1985). The Green Mountain model considered historic operations corrected to reflect full utilization of Denver's Dillon Reservoir-

Roberts Tunnel water rights. As applied to Rock Creek and Muddy Creek reservoir operations, the model assumes a water sales level of 22,800 acre-feet (the Bureau's preferred Green Mountain alternative) with a distribution and timing of demand as disclosed in the Green Mountain EIS (USDI/BR, 1985). Thus, the simulated baseline for analysis of Rock Creek and Muddy Creek impacts assumes development of a substantial increase in water demand over present conditions (see Section 3.4.1.3).

There were two areas identified in this model in which Denver required additional water. The first was in the Williams Fork to Dillon Exchange. Under this exchange, Denver may store water in Dillon Reservoir or divert out of the Blue River using the Williams Fork water right, and water is bypassed from Williams Fork to make up this diversion. The proposed reservoir would be able to make up 50 percent of this demand, thereby releasing water from either Rock Creek or Muddy Creek instead of Williams Fork or Dillon. This demand would amount to about 8,200 acre-feet per year and would peak at 15,500 acre-feet.

The second area was in relation to a natural flow release requirement, or the Williams Fork to Green Mountain Exchange (Green Mountain fill deficit). Under this exchange, Dillon is called upon to supply water to Green Mountain Reservoir up to its decreed annual fill of 152,000 acre-feet. Instead of supplying this water from Dillon Reservoir, or from Williams Fork Reservoir and paying power interference charges, water would be released from the proposed reservoir for this purpose, allowing Denver to retain water in storage in either Dillon or Williams Fork Reservoir. This demand would occur in 3 years out of the 21-year period of record analyzed, averaging 13,000 acre-feet when it occurred. The releases would most likely be made in July, August, or September when the demand at Cameo is most critical. Also, under the Denver Metro Lease, an additional 3,000 acre-feet of yield would be set aside annually to firm up Green Mountain water sales to a level in excess of the currently proposed 22,800 acre-feet annually, or to firm up Middle Park Water Conservancy District's rights in Granby Reservoir.

The projections for future water demands for western Colorado (West Slope scenario) are documented in a report entitled "A Study of Water Development Procedures and Demand Projections in the Colorado River Basin in Colorado," prepared by Western Engineers, Inc., in September 1986. In the report, future growth in the headwaters counties (Eagle, Summit, and Grand) was estimated and demands for the period 1985 to 2035 were forecast. The demands were broken into four principal categories: municipal and industrial use, ski resort development, release for snowmaking, and release for Green Mountain contract shortages. The Hydrology Technical Report contains additional details on the West Slope demand (Resource Consultants, Inc., 1987a).

4.3.3.2. Rock Creek Conditions below the Dam

Hydrology. The hydrologic conditions below the Rock Creek project were evaluated through an operational analysis of the reservoir. The operational model was developed in a spreadsheet format and consisted of a

hydrologic budget on a monthly basis. A hydrologic budget is no more than a material balance that accounts for all inputs, outputs, and changes in storage within a system defined by prescribed boundaries. In the operational model the boundaries are defined by the limits of the watershed, the inputs are the inflows to the reservoir, and the outputs are all releases from the reservoir. Releases from the reservoir include controlled releases to meet downstream demands (senior water rights, water sales, instream flows, channel maintenance flows, etc.) and uncontrolled releases as a result of reservoir spills when storage capacity is exceeded. A separate operational model was developed for the two water demand scenarios (Metro Denver Lease and West Slope).

Annual operations for the Metro Denver Lease are summarized in this section as a basis for impacts assessment. Monthly summary data for both demand scenarios are presented in Appendix A. The complete spreadsheets for the Rock Creek operational model and a discussion of the various inflows and outflows are given in the Hydrology Technical Report (Resource Consultants, Inc., 1987a). Briefly, the inflows to the Rock Creek project were developed from the Toponas gaging station and drainage area scaling for Horse Creek which enters just below the gage. Controlled releases included downstream calls on Rock Creek, the Colorado River demands, a 10 cfs instream flow, channel maintenance flows and project water sales. Reservoir spills occurred whenever the 50,700 acre-foot project storage capacity was exceeded. In a typical water year such as 1972 (see Fig. 2.4.6) the reservoir would spill during 2 months (May--2083 acre-feet and June--5962 acre-feet). Over the period of record the average annual spill would be 6985 acre-feet. Here a spill is taken to be an uncontrolled release through the outlet works or over the spillway or a combination of both.

Table 4.3.3.1 summarizes on an annual basis the discharge conditions for the Denver Metro Lease and the differences in flow as a result of the project. Fig. 4.3.3.1 compares reservoir inflow and outflow on a monthly basis. The change in outflow relative to inflow is illustrated in Fig. 4.3.3.2 and provides insight on project impacts on flow regime. The average monthly discharge below the project will be larger than pre-project conditions (inflow) during much of the year. In addition, the relative increases in flow are consistently greater than the relative decreases in flow.

The maximum increase in average annual flow below the reservoir would be experienced in 1977, an extreme dry year. In high-flow years (such as 1962 and 1970) little change in the inflow/outflow relationship would be expected. The exception would be a wet year such as 1979, when the reservoir would refill after a dry period. Fig. 2.4.6 illustrates Rock Creek Reservoir inflow, outflow, and reservoir storage for 1972, a typical year considering average inflow and average annual Metro Denver Lease demand for the period of record (see Section 2.4.7).

The Rock Creek operational analysis was completed for monthly time steps. A study of daily flows was made to evaluate the daily flow variation from mean monthly flows as a basis for impact analysis. Since the daily operations of the proposed reservoir are not known at this time, a

Table 4.3.3.1
Discharge Summary
Rock Creek Reservoir Operations

Water year	Inflow to reservoir (cfs)	Metro Denver Lease		
		Flow below reservoir (cfs)	Difference in flow (cfs)	Percent change (%)
1962	65	64	-1	-1
1963	24	36	12	50
1964	26	28	2	9
1965	41	23	-18	-44
1966	17	26	10	59
1967	29	26	-3	-11
1968	43	38	-4	-10
1969	30	35	4	14
1970	51	47	-3	-6
1971	48	43	-5	-10
1972	35	40	5	15
1973	49	43	-6	-12
1974	43	44	1	2
1975	38	40	2	5
1976	42	42	0	0
1977	13	61	48	361
1978	38	33	-5	-13
1979	51	27	-24	-47
1980	36	25	-11	-31
1981	28	44	16	59
1982	36	15	-21	-58
Average	37	37	0	0
Minimum	13	15	-24	-58
Maximum	65	64	48	361

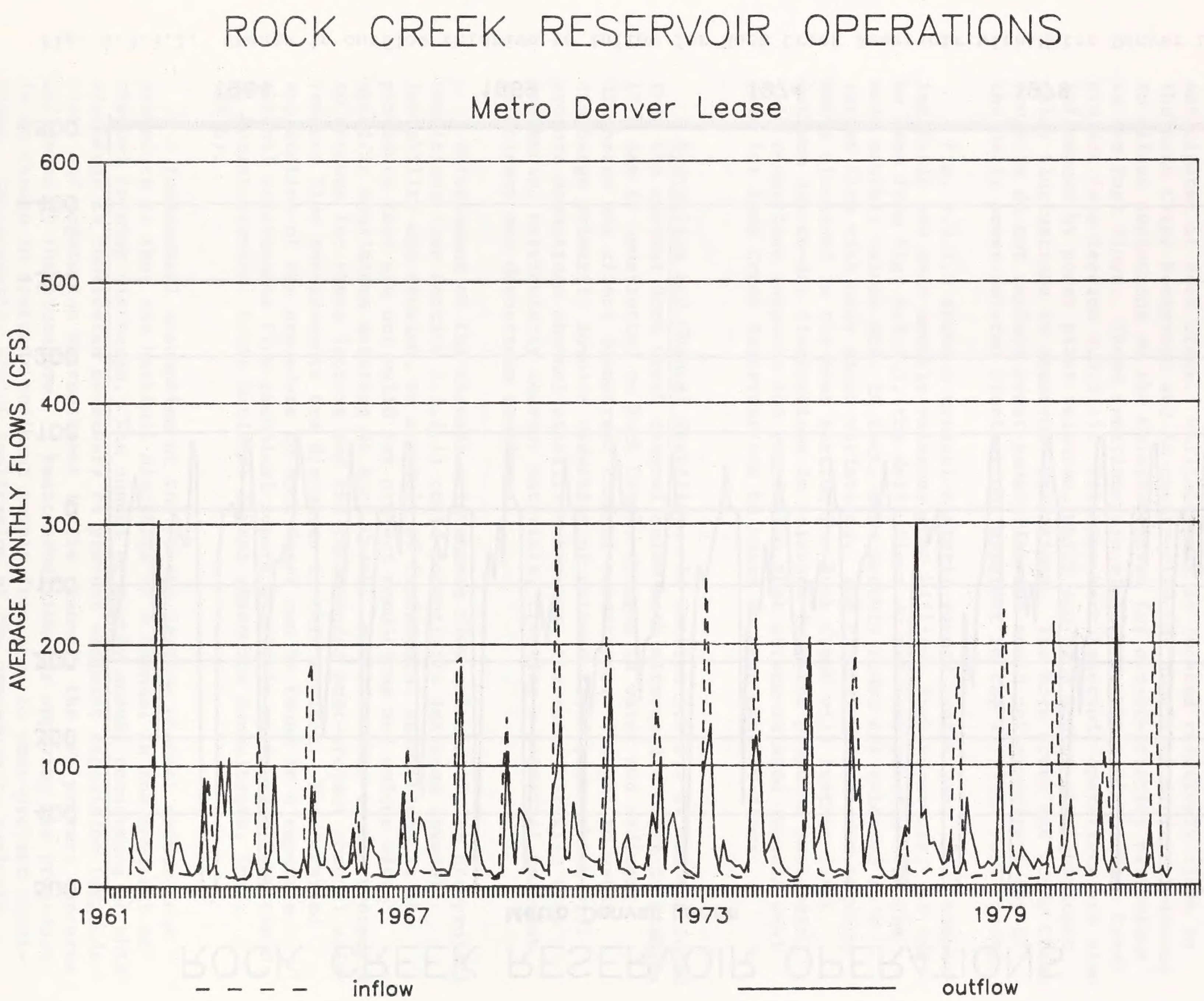


Fig. 4.3.3.1. Rock Creek Reservoir inflows and outflows with Metro Denver Lease.

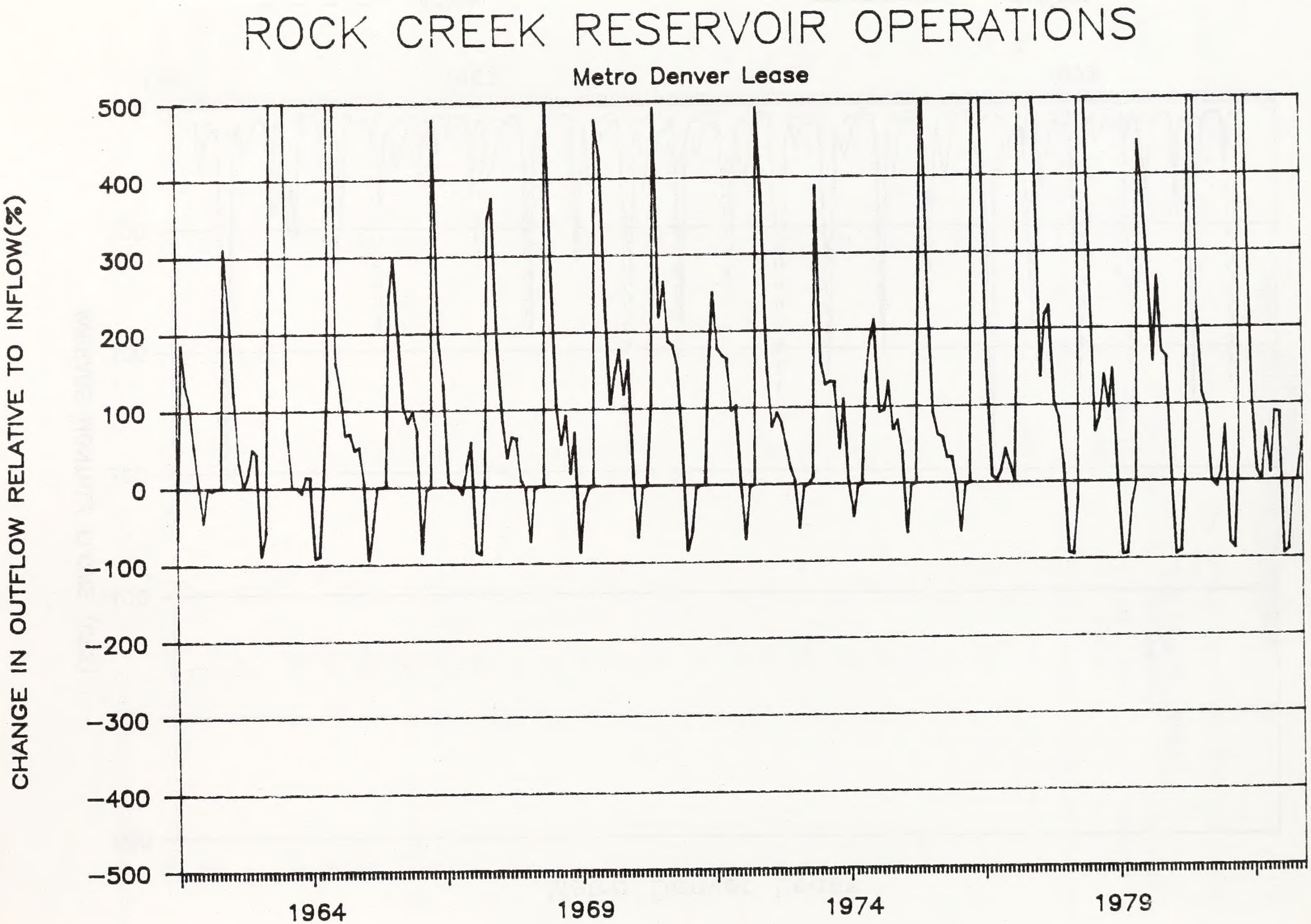


Fig. 4.3.3.2. Change in outflow relative to inflow for Rock Creek Reservoir with Metro Denver Lease.

review of historic operations of an existing project was made. Williams Fork Reservoir was selected as having operational similarities to those anticipated at Rock Creek. Williams Fork is located relatively close to the Rock Creek Reservoir and is constructed for supplying storage releases to offset depletions on the Colorado River for out-of-priority diversions to the East Slope. These functions are similar to those of the Rock Creek project (see Section 4.3.3.1). Williams Fork Reservoir operations are also influenced by power plant releases, which can be a source of significant daily fluctuations in reservoir operations. The Rock Creek and Muddy Creek projects do not include power generation and would not experience any of the daily power-related fluctuations apparent in the Williams Fork record.

Fig. 4.3.3.3 shows a typical historic record (water year 1982) comparing daily and mean monthly releases from Williams Fork Reservoir. As can be seen from Fig. 4.3.3.3, the daily flows do not vary greatly from the mean monthly values and, in fact, mean monthly flows are released as a target flow with only minor variations. The channel maintenance requirements discussed in the next section for Rock Creek will further limit maximum day-to-day fluctuations in releases from the proposed reservoir. This comparison supports the conclusion that stream-related impacts analysis for Rock Creek Reservoir can be based on mean monthly flows.

Hydraulics and Channel Stability. In Section 3.4.2.1 it was concluded that the current Rock Creek channel below both alternative sites is stable. If a dam is constructed on Rock Creek, changes in water and sediment discharge may affect downstream channel conditions. Changes in water discharge primarily involve reduction of extreme flood peaks which will promote downstream channel stability; however, the reservoir will trap sediments, particularly coarser materials, creating a potential sediment deficiency and downstream erosion.

Enforcement of the channel maintenance flow calculated for pre-project conditions (see Section 3.4.2.1) could potentially increase channel instability and erosion, as a result of fundamental assumptions in the procedure that are not valid for project conditions and unique site-specific conditions existing at Rock Creek. Modifications to the procedure to account for these factors and the recommended post-project channel maintenance flow requirements are discussed in this section. The detailed application of the procedure to Rock Creek can be found in a separate channel maintenance flow technical report available on request from the U. S. Forest Service, Routt National Forest (Resource Consultants, Inc., 1987b).

A fundamental assumption of the Forest Service channel maintenance procedure is that the bankfull discharge of a channel is the dominant or channel forming discharge. The annual or nearly annual occurrence of this discharge is considered necessary to prevent sediment deposition (aggradation) and vegetation encroachment in the channel, the two primary concerns addressed by the procedure. A basic condition for applying the procedure is no change in upstream sediment supply from pre- to post-project conditions. Consequently, strict application of the procedure to evaluate reservoir projects is questionable, since a reservoir will trap upstream sediment and release relatively clear water downstream.

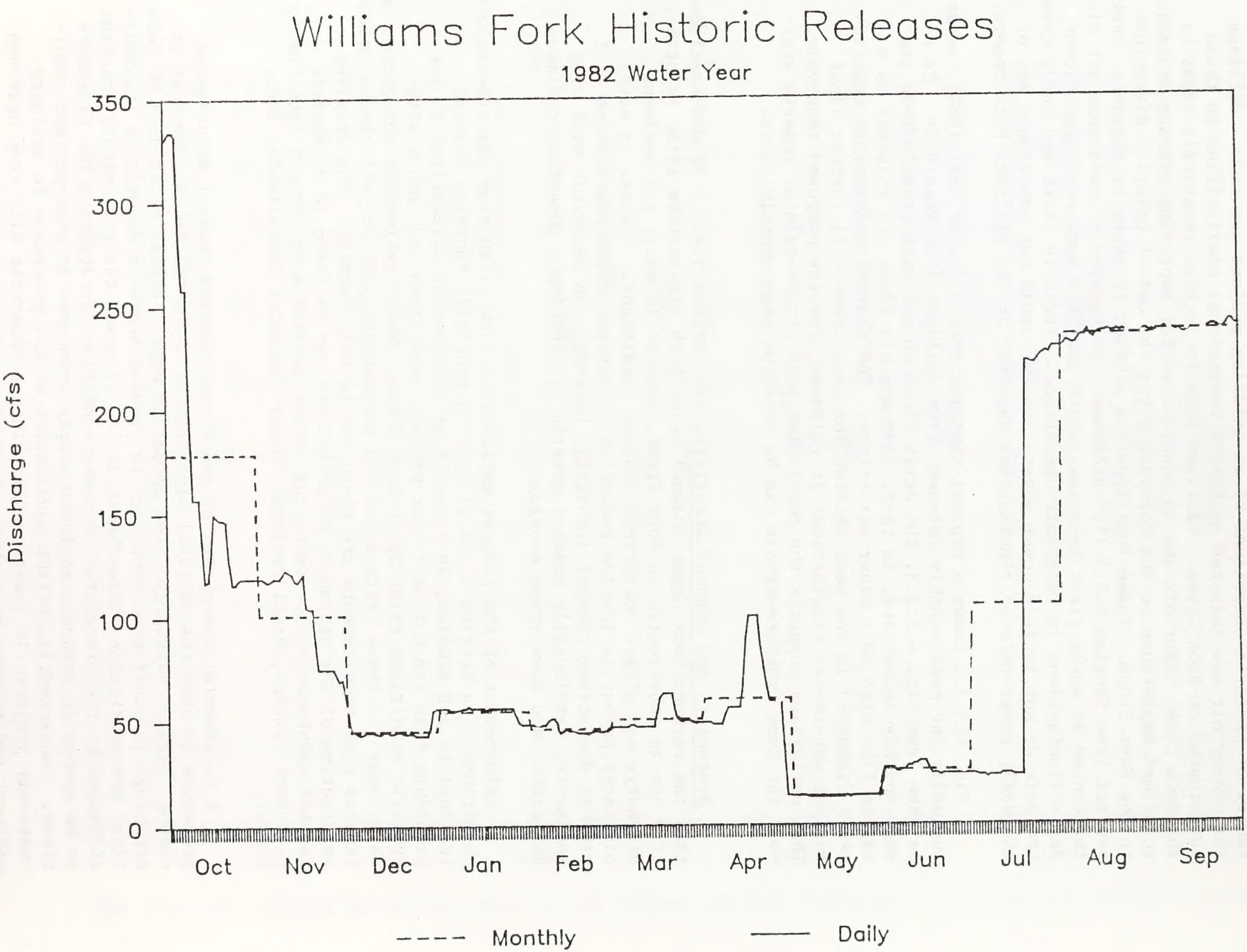


Fig. 4.3.3.3. Comparison of Williams Fork monthly and daily releases.

A related concern is the application of the procedure to a stream system in which sediment supply is limited. The procedure defines equilibrium as a condition of neither aggradation nor degradation in a stream over a short period of time. An implicit assumption in the procedure is that the sediment supplied to the channel approximately equals the channel transport capacity. For high mountain streams, this is generally true for only the coarser sizes of the bedload transport, as evidenced by the U.S. Geological Survey (1977) and by Andrews (1984). Based on analysis of 24 gravel-bed rivers in the Rocky Mountain region of Colorado, Andrews concluded that the primary source of coarse material is the channel itself and that "the bed material transport rate thus controls in large measure the quantity of coarse material supplied to a river channel." Therefore, in the absence of significant tributary sources of coarse material, the effect of reduced discharges in the main channel is to decrease the bed-material transport rate and the corresponding supply of coarse material. Under these conditions, aggradation of coarse material is not expected to occur.

In the case of Rock Creek, the only major tributary entering below the project is Egeria Creek. Aerial reconnaissance of the Egeria Creek-Rock Creek confluence revealed no evidence of delta formation or other indications of a sediment overload. Therefore, the self-regulating mechanism discussed above would control aggradation of coarse material. Consequently, the primary concerns to be addressed from application of the channel maintenance procedure to Rock Creek are the transport of fine gravels and sand particles and vegetation encroachment.

To estimate transport capacity, calculations were made based on a combination of the Einstein suspended load calculation and the Meyer-Peter, Muller (MPM) bedload equation. The MPM bedload equation has been found most applicable to coarse material systems with little suspended load and, thus, is appropriate for application to Rock Creek. The MPM calculation was calibrated against measured data by assuming that the supply of the two coarsest size fractions were in equilibrium with the transport capacity of that size fraction, as supported by Andrews (1984). Results indicated that all size fractions finer than the two coarsest fractions were supply limited; that is, transport capacity could be reduced (i.e., reduced discharge) without aggradation occurring.

The next step was to evaluate how much the discharge could be reduced under post-project conditions without the occurrence of aggradation. It was assumed that the reservoir would trap all particles in the gravel size fraction. In actuality the reservoir will probably trap all inflowing sediments (see sedimentation discussion in Section 4.3.3.3); however, assuming only the gravel fraction to be trapped results in a more conservative downstream channel maintenance flow estimate. After establishing the revised channel maintenance flows, questions on channel stability will be considered.

Based on Andrews' conclusions and the lack of significant tributary sediment sources below the reservoir, it was assumed that there would be an insignificant supply of the gravel size fraction below the reservoir. Using the calibrated transport relationships, the discharge required to

move the remaining sediment supply was then evaluated for both sites A and B. Results indicated that 85 cfs would be required below Site A to move all the pre-project supply of sediment finer than gravel, while 10 cfs would be required below Site B. It was estimated that to move all the pre-project sediment supply (including gravels) would require 30 cfs below Site B, a value that is considered a very conservative maintenance flow requirement.

These results suggested that a relatively small discharge would adequately prevent sediment deposition in the channel downstream of the project. Therefore, the flows required to minimize vegetation encroachment became the controlling factor in defining the required bypass flows. It is generally accepted that established vegetation cannot survive long periods of submergence or mean velocities higher than 5-6 fps. Under pre-project bankfull conditions (190 cfs), the mean velocity was 3.7 fps; therefore, it was concluded that a 16-day bypass time period provided an adequate length of submergence to minimize vegetation encroachment. Under the post-project 85 cfs flow necessary to prevent aggradation below Site A, the velocity is only 2.5 fps. Therefore, this flow would also be required for 16 days to minimize vegetation encroachment below the waterline. The 85 cfs flow covers 98 percent of the pre-project bankfull wetted perimeter; consequently, it can be concluded that a post-project flow of 85 cfs below Site A is as effective as a channel maintenance flow as 190 cfs was for the pre-project condition.

For Site B the 10 cfs flow required to prevent aggradation leaves a large portion of the channel bed exposed which could be encroached on by vegetation. Under the 30 cfs flow required to transport all the pre-project sediment supply, 74 percent of the pre-project wetted perimeter is covered. To provide a more significant submergence factor would require about 50 cfs, for which 89 percent of the pre-project wetted perimeter is covered. Based on these results, a 50 cfs bypass for 16 days was considered necessary to control a majority of the vegetation encroachment below Site B.

Establishment of the other flows of the post-project channel maintenance hydrograph (rise and recession flows) could not be accomplished with the USFS procedure since the procedure assumes no change in sediment supply and equilibrium conditions. However, the USFS procedure does provide an estimate of the maximum daily drawdown rate and, as discussed above in relation to encroachment, the duration of the bypass flow. Using a 20 cfs drawdown rate (from the strict application of procedure) and a 16-day bypass flow duration, the total annual bypass volume for Site A was 5858 acre-feet and for Site B, 4220 acre-feet.

Under the suggested 50 cfs bankfull discharge for Site B, both velocity (5.5 fps) and submergence contribute toward minimizing vegetation encroachment. Consequently, at Site B it may be more effective to provide higher discharges for shorter periods of time, so that a greater portion of the wetted perimeter can be inundated. Under this assumption, a modified channel maintenance hydrograph was developed that achieved a 190 cfs discharge for 2 days, providing 100 percent coverage of the pre-project wetted perimeter. The total annual bypass volume for this hydrograph was

5610 acre-feet, compared to the 4220 acre-feet volume for 50 cfs for 16 days. In other words, it takes a 33 percent greater bypass volume to prevent vegetation encroachment on 11 percent of the wetted perimeter. Fig. 4.3.3.4 illustrates the relationship of the water year 1980 hydrograph, the channel maintenance hydrograph from a strict Chapter 30 interpretation and the recommended post-project, Site B, channel maintenance hydrograph. In order to eliminate the need for mechanical maintenance, this 5610 acre-feet hydrograph is suggested as the preferred alternative and is considered as effective as the pre-project channel maintenance hydrograph which required a bypass volume of 13,200 acre-feet.

Under pre-project conditions it was established that Rock Creek is supply limited except for coarse sediment fractions. In other words, sediment supply provided to the channel is less than the transport capacity of the channel. Under these conditions erosion of the bed and banks will occur unless limited by controls, such as bedrock outcrops or armoring by coarse sediment particles. Field observations suggest that the Rock Creek channel is not eroding; therefore, geologic or geomorphic controls must be maintaining channel stability. These same controls will be acting after the dam is built, and in the case of armoring may be more effective as a result of moderation of extreme flow conditions. This is particularly true downstream of Site A where recommended project channel maintenance flows are significantly reduced from pre-project levels (85 cfs compared to 190 cfs). For Site B the magnitude of the recommended channel maintenance peak flow is unchanged (190 cfs); however, the duration has been reduced significantly which also contributes to channel stability. Additionally, the channel below Site B (through the canyon) is heavily armored at various locations contributing to general channel stability. Downstream at the confluence of Egeria Creek, a major tributary entering below the forest boundary near the Town of McCoy, the excess transport capacity will minimize potential formation of delta deposits at the Egeria Creek and Rock Creek confluence.

The Site B channel maintenance hydrograph was then incorporated into the operational model developed for Rock Creek. It was assumed that other controlled releases could be used to meet a part of the channel maintenance flow requirements. Results indicated that over the period of record used for analysis, the average annual channel maintenance flow requirement would be 699 acre-feet (in addition to other downstream requirements) under a Metro Denver Lease scenario compared to an average annual yield of about 27,000 acre-feet.

Impacts and Mitigation Summary. In summary, the changes to the surface-water resources would be primarily changes in flows resulting from reservoir operations. Impacts of modified streamflows would be primarily related to recreation and aquatic biology impacts which are discussed separately in this chapter. Project effects on Rock Creek streamflows would tend to result in decreases in flows during times when the reservoir is filling (primarily May and June) and increases in streamflows when the reservoir is releasing to replace water sales or exchanges (primarily August-October). Channel stability impacts would be insignificant since channel maintenance flows have been developed and included in the recommended reservoir operational plan. Thus, no mitigation measures are required in the area of surface-water hydrology.

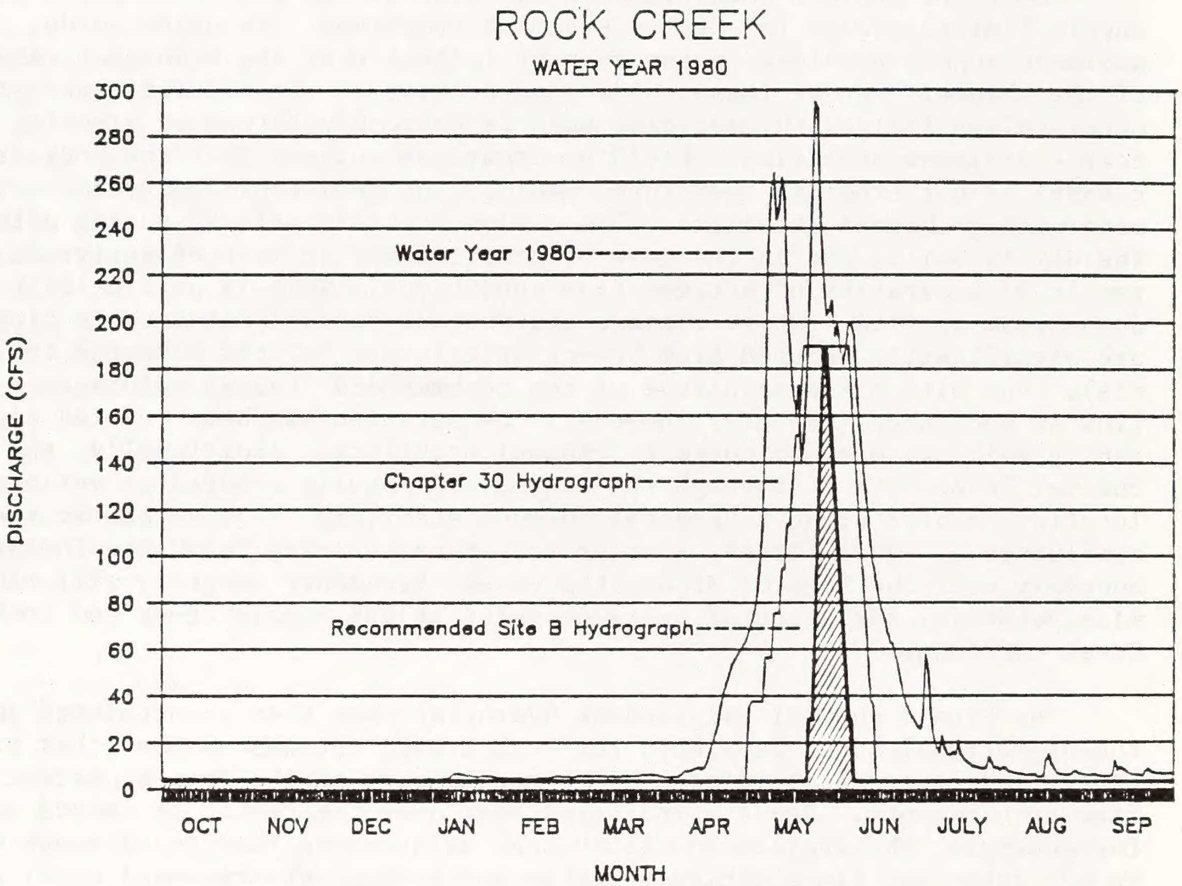


Fig. 4.3.3.4. Recommended Site B channel maintenance hydrograph compared to pre-project channel maintenance hydrograph and water year 1980 hydrograph

4.3.3.3. Rock Creek Reservoir

Operations. The operational model described in Section 4.3.3.2 also provided information on conditions in the reservoir, primarily end-of-month storage and pool elevation. Fig. 4.3.3.5 summarizes on a monthly basis Rock Creek Reservoir storage and Fig. 4.3.3.6 presents reservoir pool elevations for the Metro Denver Lease. During an extremely dry period such as 1977 reservoir operations would eliminate the conservation pool and the reservoir would be practically dry during the period and abnormally low for several years following the drought. Those conditions occurred once in the 21-year period of record analyzed. However, during this dry period Rock Creek Reservoir would be able to meet the water delivery requirements of the Metro Denver Lease. It is important to note here that because of restrictions on water yield from the Rock Creek basin it would not be practical to operate the reservoir in a manner that differs significantly from that illustrated in Fig. 2.4.6.

Pre- and post-project flows for Rock Creek near McCoy, Colorado, are evaluated in a separate hydrology technical report (Resource Consultants, Inc., 1987c). The report provides a brief hydrologic analysis of the effects of the Rock Creek Reservoir on the streamflows on Rock Creek near McCoy. The analysis used the results of previous reservoir operations studies and superimposed these studies from similar years on the measured streamflows. Results of this analysis indicated that flows would increase by about 50 percent on Rock Creek near McCoy during the October time frame, but that these increases in flows would be continued through most of the winter season as a result of the Denver Metro Lease operations. The increases in flows in October appear to be similar in magnitude to the changes experienced as a result of shutdown of irrigation diversions that historically have occurred during September and October.

Dam Failure Analysis. The possibility of dam failure and the magnitude of incurred damages is an important consideration when evaluating prospective damsites. DAMBRK, a dam-break flood forecasting model developed by the National Weather Service, was used to study the proposed damsite on Rock Creek. The model investigated the downstream channel from Rock Creek Damsite B approximately 10.9 miles through the town of McCoy to the Colorado River confluence to determine ranges for expected flood elevations and peak discharges (Resource Consultants, Inc., 1987c). The project would consist of a roller-compacted concrete dam forming a reservoir with a normal operating storage capacity of 50,700 acre-feet. The proposed dam would have a height of 175 feet above the streambed and a normal water-surface elevation of 8,681 m.s.l.

The Rock Creek dam was modeled according to the options available on DAMBRK. These options gave guidelines for describing the possible dam failure modes according to its physical characteristics. A 120-foot high railroad embankment located 3.6 miles from the proposed damsite caused the channel to act as a 2-dam system. With the construction of the Rock Creek dam, proposed as a roller-compacted concrete gravity dam, a much faster breach failure would occur as compared to an earthen dam. A concrete

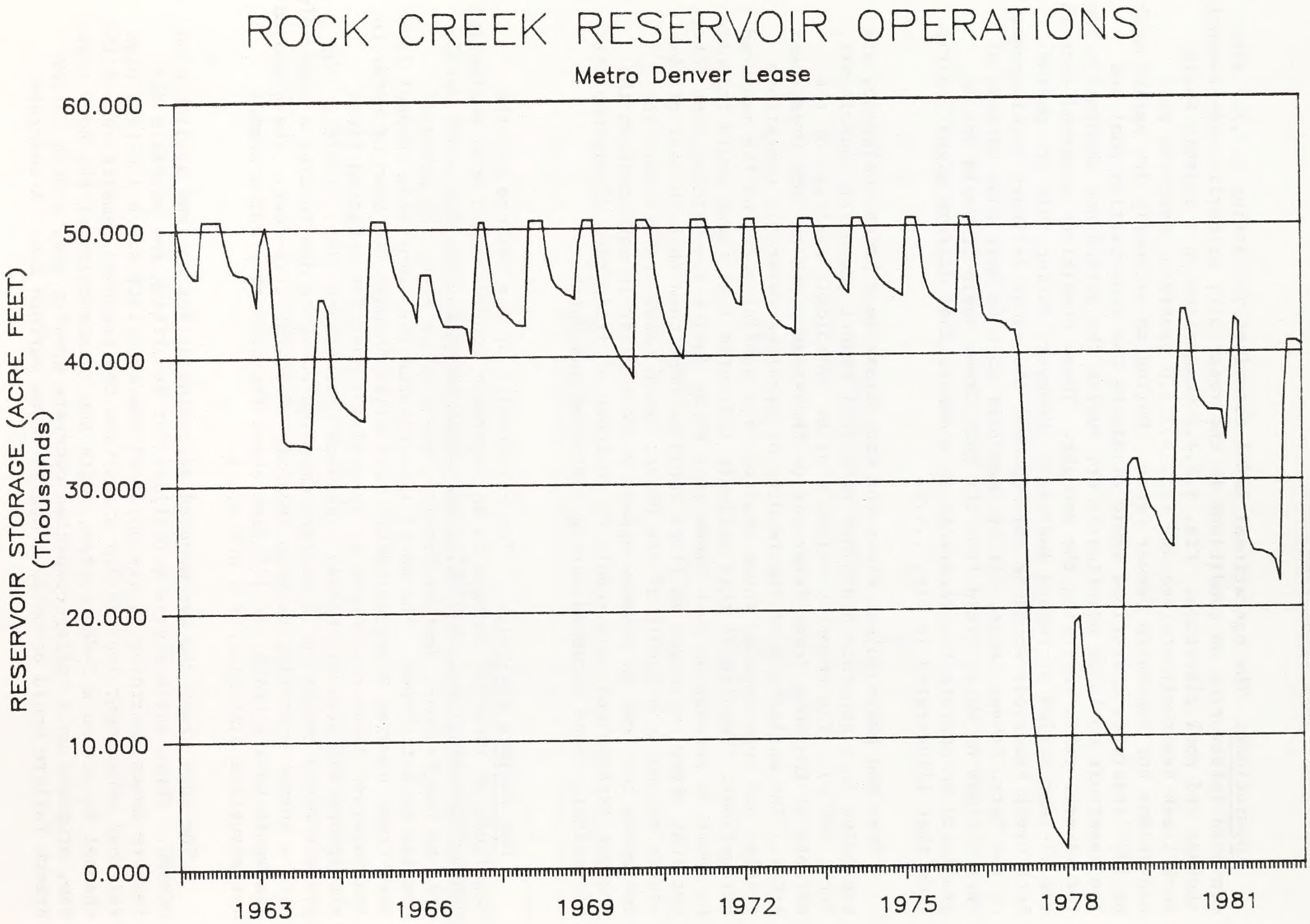


Fig. 4.3.3.5. Rock Creek Reservoir storage with Metro Denver Lease.

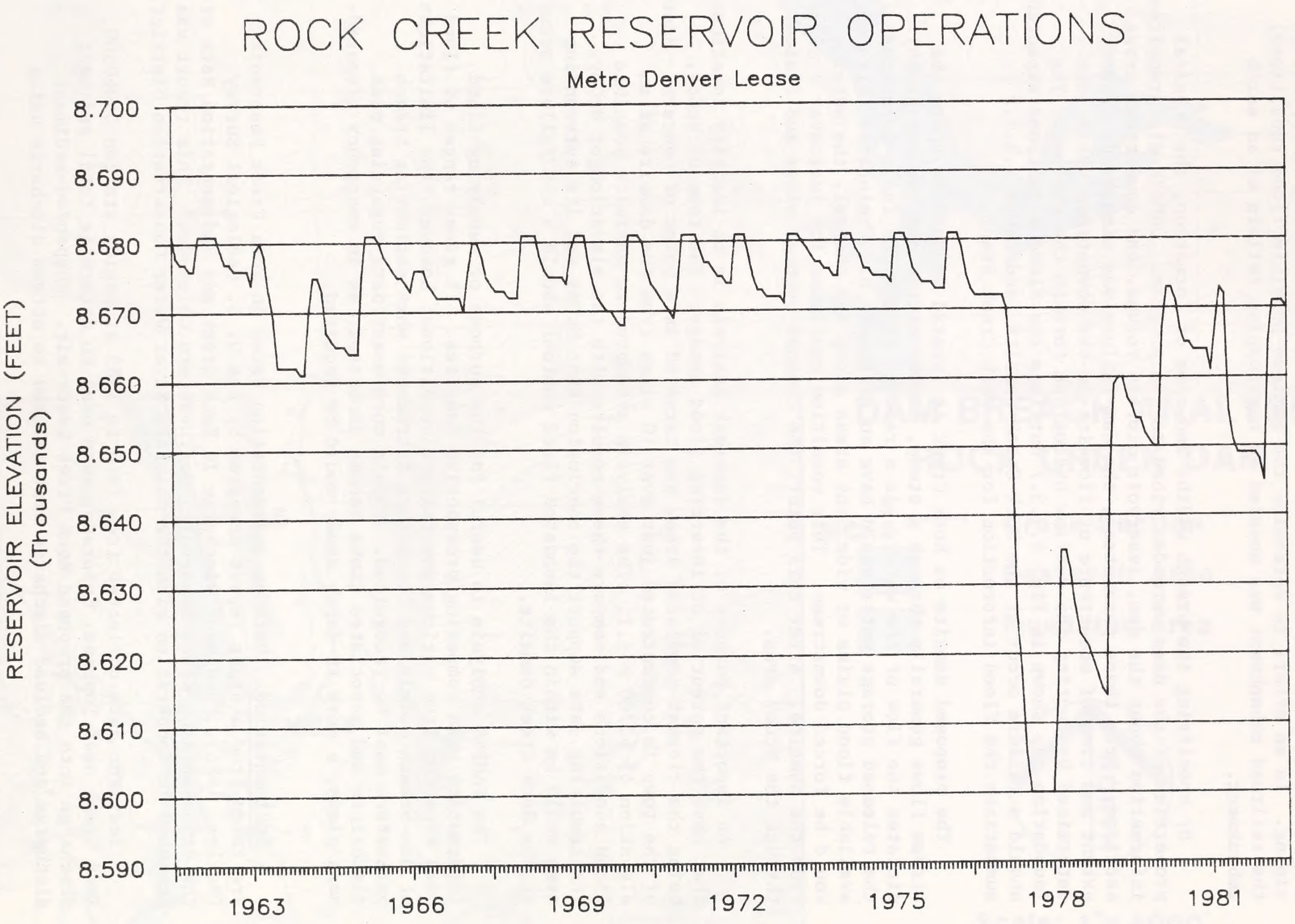


Fig. 4.3.3.6. Rock Creek Reservoir elevation with Metro Denver Lease.

gravity dam is more likely to fail by a structural shifting as opposed to piping. In an effort to determine the maximum possible flood conditions, the railroad embankment was modeled as overtopping failure of an earth embankment.

By specifying the breach widths and time of formation, the physical properties of the dams were described to the program. DAMBRK also requires information about the dam, reservoir storage volume, and downstream cross sections. From these parameters, the dam failure was simulated. The extent and time of occurrence of flooding in the downstream valley was determined by routing the outflow hydrograph through the channel. The inundation map shown in Fig. 4.3.3.7 outlines the flood elevations expected should a failure occur at the Rock Creek damsite, and Table 4.3.3.2 summarizes the flood information for the Rock Creek study.

The proposed damsite on Rock Creek is located in an area where the stream flows generally through a steep, narrow canyon and the topography dictates the flow of the water. As a result, if the dam fails (overtops), the released storage water would have an extremely high velocity. With no available flood plains or wide bank areas along the channel, the water would be forced downstream. This condition continues for just over 7 miles from the damsite. After this point, the channel becomes wider and flatter through the McCoy area.

An important purpose of the dambreak analysis is to identify locations that have the potential of incurring flood damage. The town of McCoy, being the closest populated area, was targeted as a point of concern. Most of the town is concentrated just over 10 miles from the damsite at an elevation of 6,700 m.s.l. The analysis attempted to maximize possible flood conditions and compare these results with the elevation of McCoy. The resulting data support the conclusion that McCoy and its surrounding area would be within the inundated flood contour should a dam failure occur at the Rock Creek damsite.

The DAMBRK analysis is useful for the purpose of supplying flood information when comparing prospective damsites. It gives ranges of flood data expected from various dam failure conditions; however, the limitations of dam-breach models and the errors introduced when estimating breach parameters must be recognized. Should more exact data regarding peak discharges and associated times become important, as in emergency preparedness plans, a more in-depth study would be required.

Sedimentation. Data on sedimentation rates in Rock Creek Reservoir are taken from a draft report prepared by the U. S. Geological Survey (Butler, 1986), "Sediment Discharge in Rock Creek and Sedimentation Rate of the Proposed Rock Creek Reservoir, Northwestern Colorado." This report was prepared in cooperation with the Colorado River Water Conservation District.

Sediment data collected from 1976 to 1985 at gaging station 09060500, Rock Creek near Toponas, Colorado, were used to determine total sediment discharge into the proposed Rock Creek Reservoir. Suspended-sediment discharge and bedload discharge were related to stream discharge using

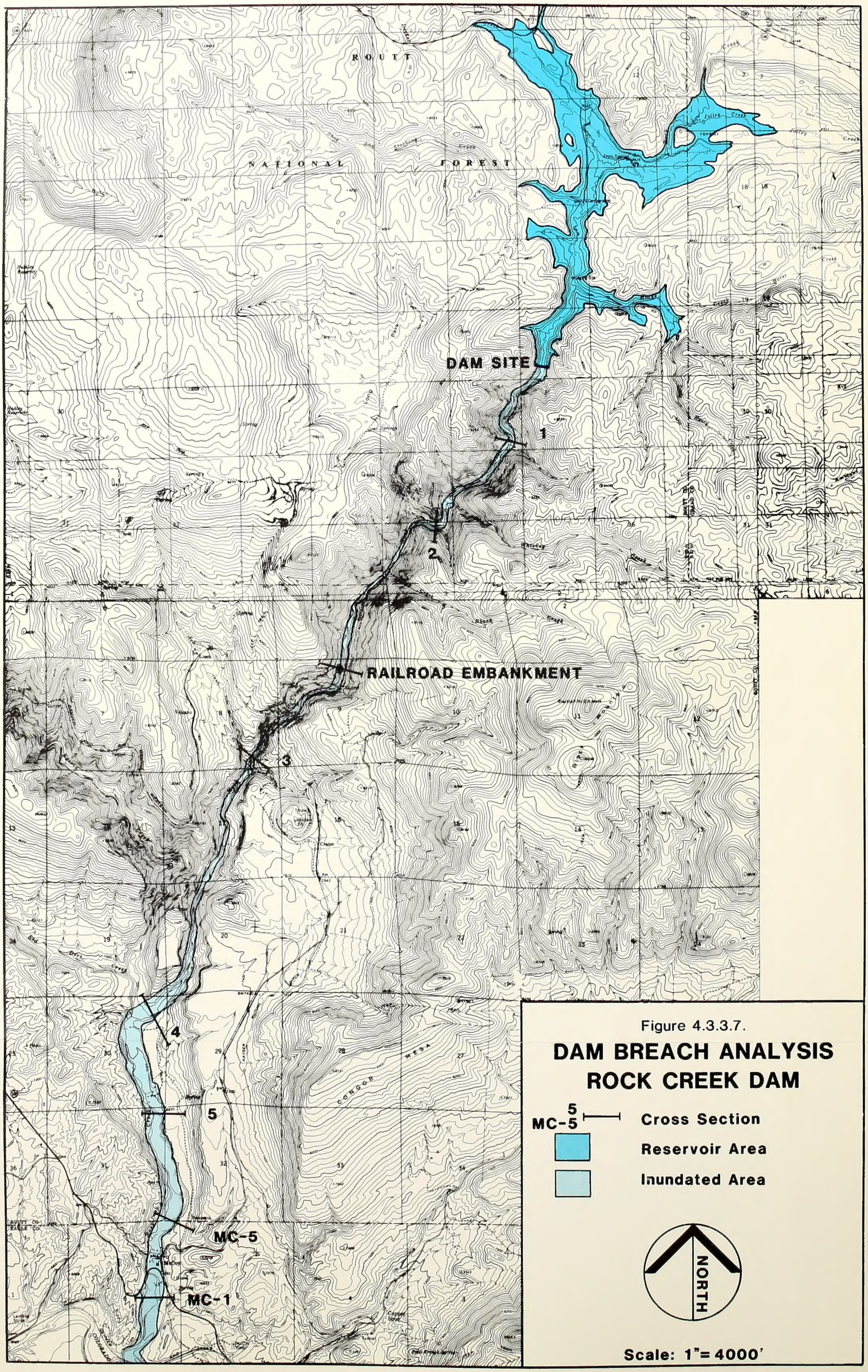


Figure 4.3.3.7.
DAM BREACH ANALYSIS ROCK CREEK DAM

Table 4.3.3.2
Dambreach Analysis
Rock Creek Damsite

Cross section	River mile from dam	Peak flow (cfs)	Max. elev. (ft)	Initial elev. (ft)	Maximum top width (ft)
Dam	0.00	610007	8588.99	8519.0	373
1	0.86	581480	8412.83	8340.0	375
2	1.93	564828	8110.47	8033.0	250
Railroad	3.61	539670	7665.66	7620.0	820
3	4.70	533883	7288.49	7220.0	209
4	7.24	522394	6892.12	6830.0	750
5	8.39	522394	6804.02	6750.0	891
MC-5	9.39	519178	6756.31	6715.0	860
MC-1	10.14	517846	6716.11	6675.0	1200

logarithmic regression relations. Mean annual suspended-sediment discharge was 230 tons per year, and mean annual bedload discharge was 190 tons per year in Rock Creek at the Toponas gaging station for 1953 through 1980 water years. The mean annual total sediment discharge into the proposed reservoir would be 460 tons per year, which includes 10 percent addition to the sediment discharge calculated for the Toponas gaging station to account for sediment discharge from Horse Creek.

Factors affecting the sedimentation rate of a reservoir include: (1) sediment and water discharge into the reservoir, (2) trap efficiency of the reservoir, (3) reservoir size and operation, (4) particle size of the sediment, and (5) specific weight of the deposits. The changes in reservoir water capacity were calculated using estimates of total sediment discharge with historical stream discharge data and information about reservoir dimensions and operational plans. Trap efficiency, the percentage of incoming sediments that remain in the reservoir, depends on reservoir size and stream discharge into the reservoir. An initial trap efficiency near 100 percent was calculated for the proposed Rock Creek Reservoir using the Churchill method. The Churchill method does not take into account sediment characteristics or many of the factors that determine sediment deposition, but does represent a very conservative approach to estimating loss in reservoir storage due to sedimentation.

Sediment inflow into a reservoir can be converted to the volume the deposits will occupy in the reservoir using specific weight of the deposits. An initial specific weight of the sediment was calculated using a method based on size distribution of incoming sediment and on a reservoir classification scheme that depends on the operational plans of the reservoir. Using a size distribution of 25 percent clay, 30 percent silt, and 45 percent sand, an initial specific weight of 71 lb/ft^3 was calculated for sediment in Rock Creek Reservoir. The specific weight of sediment deposits could vary by at least 10 percent depending on the size distribution used in the calculation. However, errors in determining specific weight will not change conclusions regarding life expectancy of the reservoir. Compaction will increase the specific weight of the deposits with time. Average specific weight of deposits for various time periods was calculated using a method described by Strand (1974). The specific weight of sediment deposits would increase to 79 lb/ft^3 after 50 years and to 80 lb/ft^3 after 100 years.

Using the total sediment discharge calculated for Rock Creek at the Toponas gage (460 tons/yr), trap efficiency (100 percent), and specific weight of sediment deposits, the volume that the deposits would occupy after various time periods was determined. The calculated volume that the sediment would occupy was subtracted from the initial water storage capacity (50,700 acre-feet) to determine changes in reservoir capacity. The capacity of the proposed Rock Creek Reservoir would decrease from 50,700 acre-feet to 50,674 acre-feet after 100 years, which is less than 1 percent reduction in water storage capacity. If total sediment discharge were underestimated by 100 percent, the annual sediment discharge would be 920 tons/year. That rate of sediment discharge would reduce the capacity of the Rock Creek Reservoir to 50,647 acre-feet after 100 years, which also is less than 1 percent reduction in water storage capacity. These

estimates indicate that sediment discharge from Rock Creek would have a very small effect on the life expectancy of the proposed reservoir.

Impacts and Mitigation Summary. Rock Creek Reservoir operations would eliminate the conservation pool during an extremely dry period such as 1977 and the reservoir would be abnormally low for several years following a drought. However, the reservoir could meet water delivery requirements of the Metro Denver Lease. The impacts would occur primarily in the aquatics and recreation areas which are discussed separately in this chapter.

The impact of the project on the community of McCoy would be the risk of dam failure. Most of the community of McCoy would be inundated as a result of a reservoir failure. The Colorado State Engineer requires frequent inspection, monitoring, and an emergency preparedness plan for each reservoir constructed in the state, which would limit and mitigate this impact. Reservoir sedimentation should not impact the project or affect the downstream channel conditions because of the small sediment load carried by Rock Creek.

4.3.3.4. Hydrology of Other Streams. To support impacts assessment for the proposed Rock Creek project, effects of streamflows were analyzed on the main stem of the Colorado River at the Kremmling gage immediately upstream of Gore Canyon and at the Dotsero gage immediately downstream of the Eagle River confluence. In addition, an analysis was made of the effects of the project on the Blue River below Green Mountain Reservoir. Using 1962 to 1982 hydrology and proposed future development schedules, the effects of reservoir operations were analyzed for the Metro Denver Lease scenario (see Section 4.3.3.1).

The effects of the proposed Rock Creek project were analyzed based on the difference in flows from the base condition of the 22,800 acre-foot sales level as simulated in the Green Mountain EIS (see Section 3.4.1.3). Details of the analysis along with assumptions behind the various calculations are summarized in a hydrology technical report available as a separate document (Resource Consultants, Inc., 1987a). Presented below is a brief description of the summary tables developed as a result of the analysis. Monthly discharge summary tables for all gaging stations are presented in Appendix A. It should be noted that at all flow stations analyzed the largest change in flow occurs between the simulated base and historic flow conditions. The change between the simulated project flows and the simulated base condition is comparatively minor.

Colorado River at Kremmling. A comparison of the annual Colorado River flow in acre-feet at Kremmling for historic conditions, project baseline, and total project flows is shown in Fig. 4.3.3.8 for the Metro Denver Lease. Table 4.3.3.3 summarizes the annual historic flows, base condition flows, and the simulated flows with the Rock Creek project. The basic effect at Kremmling would be due to water exchanges occurring upstream of Kremmling which would not be replaced until Rock Creek enters the main stem of the Colorado River below Gore Canyon at McCoy, Colorado. Effects of reservoir filling would not be seen at the Kremmling gage and therefore would not affect Gore Canyon flows.

Fig. 4.3.3.8. Simulated Colo. R. Flows At Kremmling

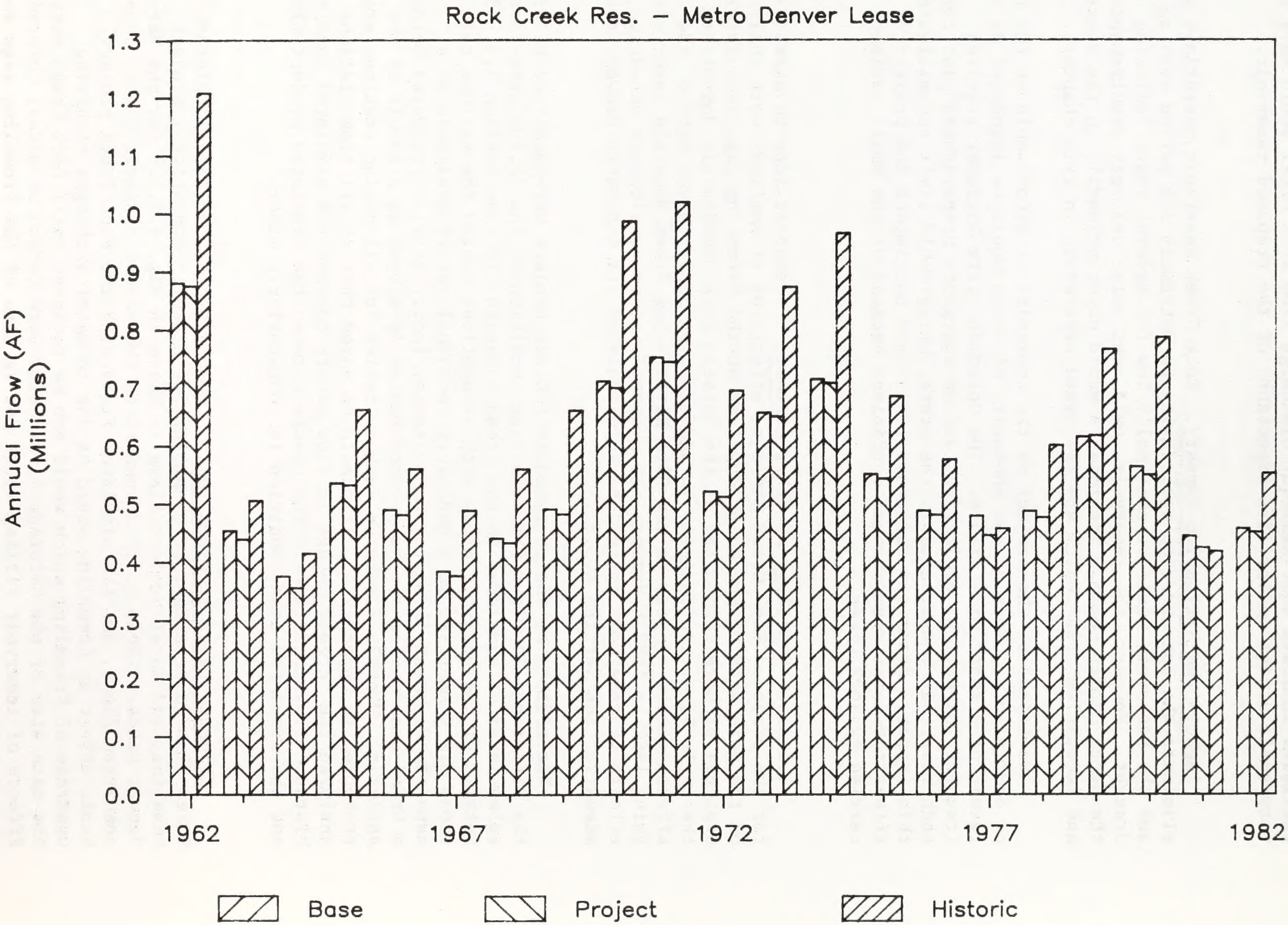


Table 4.3.3.3
Mean Annual Flow
Rock Creek Reservoir Analysis
Colorado River at Kremmling Gage

			Metro Denver Lease		
Water year	Historic flows (cfs) 1	Simulated baseline flows (cfs) 2	Simulated project flows (cfs) 3	Change in flows (cfs) 4	Percent change 5
1962	1671	1217	1211	-6	-0.52
1963	700	628	609	-20	-3.11
1964	575	521	493	-28	-5.39
1965	917	742	737	-5	-0.72
1966	775	679	666	-12	-1.81
1967	677	532	522	-10	-1.95
1968	775	610	601	-9	-1.54
1969	914	680	667	-12	-1.80
1970	1365	985	968	-17	-1.70
1971	1410	1042	1031	-11	-1.04
1972	962	722	709	-13	-1.81
1973	1208	910	901	-10	-1.07
1974	1335	989	981	-8	-0.85
1975	948	764	753	-11	-1.46
1976	798	676	666	-10	-1.46
1977	633	663	618	-46	-6.88
1978	832	675	660	-14	-2.13
1979	1061	852	855	3	0.31
1980	1088	781	761	-20	-2.50
1981	580	615	588	-27	-4.39
1982	765	634	626	-8	-1.34
Average	952	758	744	-14	-1.9
Maximum	1671	1217	1211	3	0.3
Minimum	575	521	493	-46	-6.9

Column 1 of Table 4.3.3.3 is the historic average monthly flow in cfs as measured at the USGS gaging station. Column 2 is the simulated monthly flow for the base condition of the recommended 22,800 acre-foot sales level for the Green Mountain EIS. The large difference between column 1 and column 2 is a result of the Green Mountain model assumption that water diversions through the Roberts Tunnel and Windy Gap are exercised to their allowable legal capacity (significantly greater than their historic diversions). Column 3 presents simulated flows based on the Rock Creek Reservoir operations and column 4 is the difference from the simulated base condition. Column 5 is the percentage change in the base condition as a result of the Rock Creek project.

Colorado River at Dotsero. A comparison of the annual Colorado River flow in acre-feet at Dotsero for historic conditions, project baseline, and total project flows is shown in Fig. 4.3.3.9 for the Metro Denver Lease. Table 4.3.3.4 presents the changes in flows that would occur at Dotsero as a result of the Rock Creek project. At the Dotsero gage effects of Rock Creek Reservoir operations would occur only at times when the reservoir is filling. Metro Denver Lease exchanges would occur upstream of the gage and therefore would be replaced downstream of the Rock Creek confluence. Columns in the table are the same as in the previous table for Kremmling.

Blue River. A similar analysis was completed for the Blue River below Green Mountain Reservoir for the Metro Denver Lease. A comparison of the annual Blue River flow in acre-feet below Green Mountain Reservoir for historic conditions, project baseline, and total project flows is shown in Fig. 4.3.3.10. Table 4.3.3.5 summarizes the changes of flow developed in this analysis. Water sales and exchanges would occur above Green Mountain Reservoir which would account for the depletion to the Blue River. Because of diversions through the Roberts Tunnel above Dillon Reservoir, the Blue River below Dillon will experience fewer periods of flows which exceed the minimum 50 cfs release from Dillon. Again, the columns of Table 4.3.3.5 are the same as previously described. A summary of the impacts of Rock Creek operations averaged over the period of record at the three gaging stations is presented in Table 4.3.3.6.

In relation to mean monthly flows analyzed, daily fluctuations in flows due to sales above Green Mountain Reservoir will not significantly change Blue River flows below Green Mountain. Water demand variations for municipal uses and snowmaking would be buffered by Green Mountain Reservoir operations and would be small in comparison to flow changes due to existing power release fluctuations from Green Mountain.

Impacts and Mitigation Summary. The Metro Denver Lease would result in diversion of approximately 11,000 acre-feet of water annually from the Colorado River basin with out-of-priority diversions being met by reservoir release. Project impacts on surface-water resources of other streams would be limited. The Blue River below Dillon Reservoir would experience fewer periods of flow which exceed the 50 cfs minimum release from Dillon. Impacts on recreational resources and aquatic biology are discussed in separate sections of this chapter.

Fig. 4.3.3.9. Simulated Colo. R. Flows At Dotsero

Table 4.3.3.4
Mean Annual Flow
Rock Creek Reservoir Analysis
Colorado River at Dotsero Gage

Water year	Historic flows (cfs) 1	Simulated baseline flows (cfs) 2	Metro Denver Lease: Simulated project flows (cfs) 3	Metro Denver Lease: Change in flows (cfs) 4	Metro Denver Lease: Percent change 5
1962	3200	2745	2736	-9	-0.34
1963	1388	1314	1304	-10	-0.77
1964	1325	1269	1251	-17	-1.35
1965	2188	2012	1985	-27	-1.32
1966	1487	1388	1382	-5	-0.40
1967	1484	1337	1321	-17	-1.24
1968	1740	1573	1557	-16	-1.04
1969	1846	1610	1599	-11	-0.68
1970	2638	2256	2234	-23	-1.00
1971	2625	2255	2237	-18	-0.81
1972	1921	1679	1668	-11	-0.63
1973	2430	2130	2113	-18	-0.84
1974	2519	2171	2161	-10	-0.47
1975	2177	1990	1978	-12	-0.61
1976	1728	1604	1592	-13	-0.78
1977	1117	1144	1145	0	0.01
1978	1983	1824	1803	-21	-1.16
1979	2320	2110	2082	-28	-1.33
1980	2186	1877	1843	-34	-1.79
1981	1203	1236	1221	-14	-1.14
1982	1891	1758	1725	-33	-1.87
Average	1971	1775	1759	-16	-0.9
Maximum	3200	2745	2736	0	0.0
Minimum	1117	1144	1145	-34	-1.9

Fig. 4.3.3.10. Simulated Blue River Flows

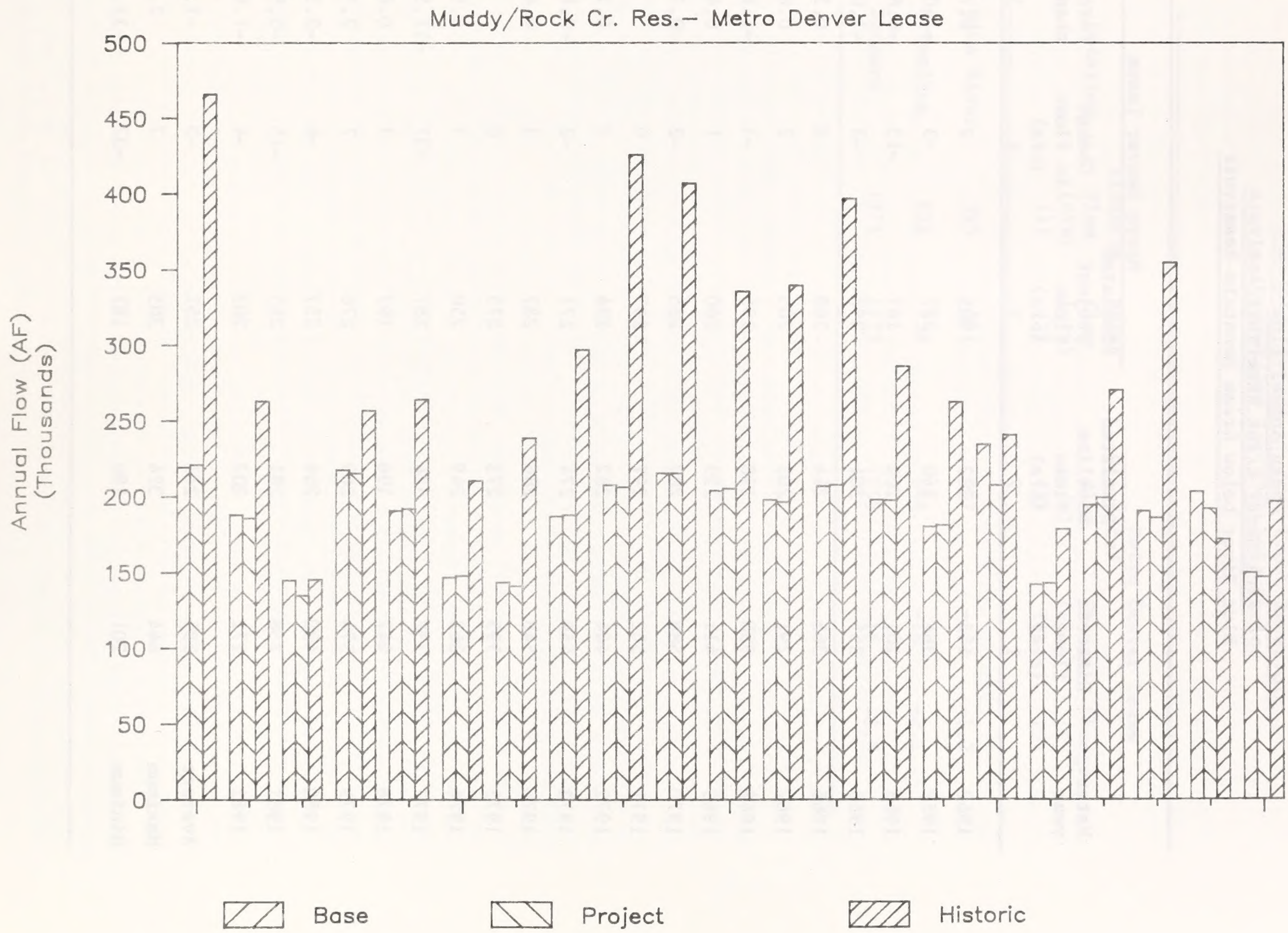


Table 4.3.3.5
Mean Annual Flow
Rock/Muddy Creek Reservoir Analysis
Blue River below Green Mountain Reservoir

			Metro Denver Lease		
Water year	Historic flows (cfs) 1	Simulated baseline flows (cfs) 2	Simulated project flows (cfs) 3	Change in flows (cfs) 4	Percent change 5
1962	644	303	305	2	0.73
1963	364	260	257	-3	-1.08
1964	201	200	187	-13	-6.69
1965	355	301	298	-3	-1.08
1966	365	264	265	2	0.58
1967	291	203	205	2	0.82
1968	330	198	195	-3	-1.64
1969	411	259	260	1	0.47
1970	588	287	285	-2	-0.77
1971	562	297	297	0	0
1972	464	282	284	2	0.79
1973	469	274	271	-2	-0.81
1974	548	286	287	1	0.40
1975	395	273	273	0	0
1976	363	249	250	1	0.50
1977	332	324	287	-37	-11.53
1978	247	196	197	1	0.68
1979	374	269	276	7	2.56
1980	490	264	257	-6	-2.34
1981	238	281	265	-15	-5.51
1982	272	207	203	-4	-1.88
Average	395	261	257	-3	-1.3
Maximum	644	324	305	7	2.6
Minimum	201	196	187	-37	-11.5

Table 4.3.3.6
Simulated Impact of Rock Creek Reservoir
Operations for 1962-1982 Period

Location	Historic flow (cfs) (1)	Base flow (cfs) (2)	Metro Denver Lease: Simulated flow (cfs) (3)	Metro Denver Lease: Change (cfs) (4)	Metro Denver Lease: Change (%) (5)
Blue River	395	261	257	- 3	-1.2
Kremmling	952	758	744	-14	-2.1
Dotsero	1971	1775	1759	-16	-0.9

4.3.3.5. Water Quality

Rock Creek. Anticipated water quality impacts may be examined as three separate items: construction phase, reservoir area, and downstream area.

Construction Phase. The impacts to water quality from the construction phase are largely related to sediment production and water quality concerns from the use of heavy equipment near surface waters and the stream channel. Principal activities that may impact water quality include stripping topsoils and exposing subsoils, gravel mining operations in and around the live stream and the potential compaction of soils by construction machinery resulting in reduced infiltration rates.

Factors affecting sediment and other pollutant loss from construction sites include slope, proximity to the stream channel, vegetation buffer zones between the activity and channel, erodibility of soils, meteorological factors, length of time soils are exposed, and timing of the activities with regard to the stream hydrology.

Avoidance of water quality impacts during construction would be accomplished by erosion and sediment control techniques and activity scheduling. The project contractor and subcontractors would be required to comply with applicable Federal, State, and local laws, regulations, and permits concerning the control and abatement of water pollution. Construction activities would be performed by methods that would prevent entrance or accidental spillage of solid matter, contaminants, debris, and other pollutants into any water source. Such pollutants include, but are not restricted to, refuse, garbage, cement, concrete, oil and other petroleum products, and aggregate processing tailings.

During the construction phase, all contracts would specify that the contractor would provide and implement an erosion control plan that would comply with State requirements for erosion control dams and with the Colorado Pollutant Discharge System permit. These include (1) using the minimum number of stream diversions possible, placed early in the construction period; (2) an undisturbed buffer zone 50 feet wide on each side of the channel; (3) excavated materials would not be stockpiled or deposited near streams or wetlands; (4) clearing of the reservoir would be done as late as the construction schedule would allow; and (5) to the maximum extent possible, equipment for instream construction would operate from the streambanks, rather than in the stream. See Appendix C for additional discussion of soil and water monitoring and erosion/sediment control requirements. Following such procedures, no significant impacts to water quality would be anticipated during construction.

Rock Creek Reservoir. In temperate climates reservoirs may experience summer temperature/density stratification, in which the warmest, lightest waters will be found at the surface and the coolest, heaviest waters will be found at the bottom.

Thermal stratification occurs in many natural lakes and man-made reservoirs. The amount and duration of this stratification depends on the water body geometry, flow, wind direction and velocity, and solar radiation. One means of predicting whether or not a reservoir will stratify is through the use of the densimetric Froude number (F). If F is less than the reciprocal of pi, stratification is expected, with the degree of stratification increasing as F becomes smaller (Canter, 1985). The Froude number may be approximated by

$$F = 320\ (Q/V)\ (L/D)$$

where L = reservoir length (m)
D = mean reservoir depth (m)
Q = discharge through the reservoir (cu. m/sec)
V = reservoir volume (cu. m)

Using average annual values, it was determined that the proposed reservoir on Rock Creek would stratify. A temperature model was not developed for the reservoir due to the lack of supporting data.

A eutrophication analysis can be based on the assumption that phosphorus is the most important factor limiting algal growth. Thus, phosphorus concentrations can be used as an indicator of trophic state. The phosphorus flux calculated for Rock Creek was 2.3 Mg/yr or 0.57 $g/m^2/yr$ (see Table 3.4.9). Given normal reservoir operations, surface area and volume estimates were used to calculate the mean depth. The mean depth of 15m and phosphorus loading suggest that the reservoir would be eutrophic (Vollenweider, 1968). A better approximation of the phosphorus loading, using hydraulic considerations is the Canfield-Bachmann model (Canfield-Bachmann, 1981). This model predicted phosphorus concentrations of 0.025 mg/L which is mesotrophic to slightly eutrophic. The role of phosphorus mass balance modeling and its relation to potential eutrophication has been shown to be valid for planning purposes (Mueller et al., 1981). A slightly eutrophic status in a reservoir at this elevation would not cause a significant water quality problem.

Water quality changes downstream and in the reservoir need to be better determined before specific mitigation can be proposed. Additional water quality monitoring and temperature modeling during the design phase and the early years of reservoir operation would better quantify the potential water quality changes. If modeling during the design phase indicates that a multiple level outlet structure would enhance downstream temperature and water quality characteristics, that capability could be added to the project.

The Rock Creek areal loadings are 0.57 $g/m^2/yr$ for P and 5.40 $g/m^2/yr$ for N (Table 4.3.3.7). The phosphorus load is between that of Dillon and Green Mountain reservoirs, however the nitrogen load is significantly less. The low P load in Dillon is attributed to tertiary wastewater treatment plants in the watershed. Nonetheless, the bulk of the P load in Green Mountan is from Dillon Reservoir outflow via the Blue River (Lewis et al., 1984). If phosphorus is the most important factor limiting algal growth, water quality in the proposed Rock Creek Reservoir should be comparable to Dillon and Green Mountain reservoirs.

Table 4.3.3.7
Surface Loading for Nitrogen and Phosphorus in Rock Creek, Green Mountain, Dillon, and Muddy Creek Reservoirs

Reservoir	P load $g/m^2/yr$	N load $g/m^2 yr$	N:P
Rock Creek	0.57	5.40	10:1
Green Mountain	0.77	27.36	35:1
Dillon	0.36	10.95	30:1
Muddy Creek	0.85	9.68	11:1

The reservoir would receive additional inputs of plant nutrients by the decomposition of plants and soil organic matter when the reservoir is filled for the first time. This flush of nutrients could last 2 to 4 years and increase productivity (Sylvester and Seabloom, 1964). As described in Chapter 3, the nitrogen and phosphorus estimates at Toponas are higher than the probable inflow to the reservoir once established and represent a conservative estimate. No estimate of the mobilization of iron and manganese was made, nor was their impact on dissolved oxygen kinetics assessed.

Temperature, turbidity, and nutrients would be the most important factors limiting biological productivity. Because of the high elevation (8,690 ft), the expected water temperatures would be cool and limit productivity. Rock Creek has an average inflow of 26,082 acre-feet and storage of 50,900 acre-feet or an approximate average detention time of 1.95 years. The detention time could result in more nutrients being available for in-reservoir primary production, but cool temperatures could limit primary productivity.

Rock Creek suspended sediment concentrations were generally low (Butler, 1986). Suspended sediment concentrations increased with increased stream discharge. The average suspended sediment sample was composed of 25 percent clay, 30 percent silt, and 45 percent sand. The suspended sediment load was 230 tons/yr or approximately 55 percent of the total load. Given an average detention time of 1.95 years, there is a greater chance (or time) for particles to settle, thus downstream discharges could generally have less suspended sediment and turbidity than existing conditions.

Dillon Reservoir is ice covered January through April, and Green Mountain Reservoir starts freeze-up in November with ice break-up in late April or in May. Given the higher elevation of Rock Creek, freeze-up could probably be extended on both ends of the winter period.

The development of the Rock Creek Reservoir would result in the inundation of Iron Spring. It was not determined if the reservoir head would abate the Iron Spring flow. The contribution of Iron Spring to reservoir water quality parameters would be insignificant given the size of the spring in comparison to the storage volume of the proposed reservoir. Analysis of samples from Iron Spring (see Section 3.4.3.1) indicates that hydrogen sulfide gas was below detection limits and could not adversely affect water quality and aquatic habitat in the proposed reservoir.

<u>Rock Creek below the Dam</u>. Water quality in Rock Creek was characterized in Chapter 3 (Section 3.4.3.1). Downstream water quality impacts are largely related to physical changes due to temperature differences. When a reservoir is built in a natural stream, downstream physical changes that may be expected include: lower summer maximum temperature, warmer winter minimum temperature, dampening of day-to-day and day-to-night temperature changes, delayed summer maximum temperature and delayed winter minimum temperature (Jaske and Goebel, 1967; Ward, 1976a; and Ward, 1976b). In many cases, macroinvertebrate populations are increased. This, along with warmer winter temperatures may favor sport fishing but reduce species diversity (Ward, 1976b).

Changes in streamflow below the dam can affect the water quality constituent concentrations that are flow related. The effect of altered streamflows may change the nutrient flux below the dam, however the natural variations are as large or larger than potential changes with the proposed dam. Potential changes in water quality below the dam are insignificant given the proposed operating schedule. Any impacts to the Colorado River would be indiscernible. There are no measurable differences in water quality impacts between the proposed or alternate damsites.

Given the detention time and potential for stratification, and the proposed single outlet, streamflow below the dam will remain constant at 4°C since the water will be withdrawn from the hypolimnion. Specific reservoir temperature modeling was not done due to the lack of meteorological data.

Reservoir operations would deplete the reservoir volume during extreme dry years (see Fig. 4.3.3.5) and the temperature of outflow water would be controlled by inflow temperatures. In general, water withdrawal from the hypolimnion would have a temperature of 4°C, the temperature at which water has the maximum density. Water withdrawal from the bottom would increase the flushing of nutrients through the reservoir, increase circulation, and decrease themal stratification and related depletion of dissolved oxygen.

Given the present water quality data base and potential short-term and minor water quality impacts, the chemical, physical, and biological (in terms of water quality) integrity of Rock Creek would not be adversely impacted.

Mitigation. For Rock Creek there would be no significant adverse impacts to water quality. Therefore, no mitigation would be required.

4.3.3.6. Unavoidable Adverse Impacts. There are no significant unavoidable adverse impacts in relation to surface-water resources.

4.3.4. Ground-Water Resources

4.3.4.1. Anticipated Impacts. Changes to the ground-water resources of the Rock Creek basin would be limited. Local changes in the ground-water table would be experienced as the reservoir fills and releases. Some increase in the water table could be experienced immediately downstream from the dam due to seepage. One spring, the Iron Spring, referenced in Section 3.5.1, would be in the reservoir basin and would be lost.

4.3.4.2. Mitigation. No mitigation would be required for the impacts to the ground-water resource.

4.3.4.3. Unavoidable Adverse Impacts. Other than the loss of one spring known to be visited by local residents there would be no unavoidable adverse impacts to the ground-water resource of the Rock Creek basin.

4.3.5. Air Quality

4.3.5.1. Anticipated Impacts. Air quality impacts may occur from construction activity. Dust and smoke would be associated with the construction phase. Noise would also be a short-term impact. Secondary impacts to air quality may be generated from recreation parking areas, however the impact would not be significant. Given the location and topography of the reservoir basin, the occurrence of fog along Highway 134 should not be exacerbated.

4.3.5.2. Mitigation. Appropriate mufflers and other exhaust filters would minimize most air quality impacts. Activity scheduling may be required during inversions or other inclement weather periods.

Measures would be implemented to reduce dust from such construction activities as travel on dirt and gravel roads, excavations, quarries, aggregate plants, and storage areas. Measures would include limiting such activities to the minimum area possible for the shortest possible period, use of dust suppressants, and revegetation. The contractor would furnish all labor, equipment, and materials required to control fugitive dust in compliance with Federal, State, and local regulations. Contractors would be expected to use such methods and devices as are reasonably available to control, prevent, and otherwise minimize noise, vehicle and plant emissions, and discharges of atmospheric contaminants.

4.3.5.3. Unavoidable Adverse Impacts. No unavoidable adverse impacts are expected on air quality.

4.3.6. Vegetation. Impacts associated with the construction and operation of this alternative include the loss of vegetation due to inundation, and loss and disturbance of vegetation due to construction of project components such as the dam, roads, recreation facilities, and transmission line relocation. A reduction in the areal cover of vegetation communities, except wetlands, would not be considered significant because these communities are common, of wide distribution, and occur with high frequency within the general area of the project. The usefulness of these vegetation types would be lost in terms of utilization by wildlife and range livestock, as well as utilization for timber products and outdoor recreation. The loss of wetlands, which is considered significant, is discussed in greater detail under Sensitive Species and Communities, Section 4.3.6.1.

4.3.6.1. Anticipated Impacts

General Vegetation

Inundation. Construction and operation of Dam Site B would result in inundation of approximately 1,070 acres of land, or 6 percent of the 19,650 acre study area, at the normal maximum reservoir operating level. Of this total, approximately 18 acres of forest, or less than 1 percent of the forested area; 577 acres of sagebrush complex, or 15 percent; and 477 acres of wetland, or 26 percent of wetlands in the study area would be inundated. These losses are summarized in Table 4.3.6.1. Figure 3.7.1 shows the distribution of these types within the inundation area.

The shoreline zone of the reservoir would not revegetate naturally because the continual fluctuation of the water level would not provide the stable environment required for the establishment of vegetation.

Facilities Construction. Construction of the dam, dam access road, campground and day use areas, reservoir overlook, and the relocation of Highway 134 and the transmission line would result in loss of vegetation. Table 4.3.6.1 summarizes the acreages of vegetation types that would be lost due to construction and operation of facilities associated with the Rock Creek reservoir.

Borrow areas would be established in the bottom of the Rock Creek drainage within the reservoir inundation area and thus are included in the inundation impacts.

The campground would be located in approximately 25 acres of forest and 15 acres of sagebrush association types. A minimal amount of vegetation disturbance and destruction, which would not be considered significant, would occur as a result of constructing the roadways and campsites.

The day use facilities would be located in approximately 15 acres of sagebrush association and 5 acres of forest. A minimal amount of vegetation disturbance and destruction, which would not be significant, would occur as a result of constructing the roadways, picnic sites, parking lot, and boat ramp.

Weedy exotic plant species may invade the areas disturbed by facilities construction. The probability of a significant problem developing as a result of the establishment of such species would be very low to moderate.

Sensitive Species and Communities. No federally listed or candidate plant species, or species of state concern would be impacted as a result of implementing this project.

Table 4.3.6.2 summarizes the impacts to wetland vegetation described below by type for the components of the project. Figure 3.7.1 shows the type and distribution of wetlands that would be lost due to inundation.

Table 4.3.6.1. Loss of vegetation community types due to facilities construction and inundation at the Rock Creek Site.

Project Component	Forest (ac)	Sagebrush Association (ac)	Wetland (ac)	Total (ac)
Facilities				
Access road[1]	6.8	11.0	7.5	25.3
Highway[2]	0.0	4.4	1.1	5.5
Powerline[3]	7.6	1.0	0.1	8.7
Campground[4]	2.0	1.0	0.0	3.0
Day use facilities[5]	1.5	1.0	0.0	2.5
Overlook[6]	0.0	1.0	0.0	1.0
Subtotal	17.9	19.4	8.7	46.0
Percent of total in study area	0.1%	5.5%	0.5%	0.2%
Dam Site B				
Construction[7]	0.0	3.0	0.5	3.5
Inundation[8]	18.0	577.0	477.0	1,072.0
Subtotal	18.0	580.0	477.5	1,075.5
Total (including subtotal above)	35.9	599.4	486.2	1,121.5
Percent of total in study area	0.3%	15.6%	26.6%	5.8%

1- assuming a 40 foot wide right-of-way along a 5.2 mile length.
2- assuming a 75 foot wide right-of-way along 3,210 feet.
3- assuming a 50 foot wide right-of-way in forest and minor amounts in sagebrush complex and wetland along its 3.6 mile length.
4,5,6- assuming a minimal hypothetical amount of disturbance.
7- based on location of dam site and topography.
8- inundation at normal maximum reservoir operating level.

Table 4.3.6.2. Summary of wetland losses due to inundation and facilities construction by wetland type for Rock Creek Dam Site B.

Project Component	Wetlands: Wet Subirrigated Meadow (ac)	Wetlands: Willow Riparian (ac)	Wetlands: Stream (ac)	Wetlands: Ponds (ac)	Wetlands: TOTAL (ac)	Uplands: TOTAL (ac)
Access Road	2.5	4.9	0.1	0.0	7.5	25.3
Highway	1.1	0.0	0.0	0.0	1.1	5.5
Transmission line	0.1	0.0	0.0	0.0	0.1	8.7
Campground	0.0	0.0	0.0	0.0	0.0	3.0
Day Use Facilities	0.0	0.0	0.0	0.0	0.0	2.5
Overlook	0.0	0.0	0.0	0.0	0.0	1.0
SUBTOTAL	3.7	4.9	0.1	0.0	8.7	46.0
Percent of Total In Study Area	<1.0	<1.0	<1.0	0.0	<1.0	<1.0
Dam Site B						
Construction	0.0	0.4	0.1	0.0	0.5	3.5
Percent of Total Construction	0	80	20	0	100	100
Inundation	210.0	245.0	20.0	2.0	477.0	1072.0
Percent of Total Inundation	44	52	4	<1	100	100
TOTAL (including SUBTOTAL above)	213.7	250.3	20.2	2.0	486.2	1121.5
Percent of Total In Study Area	25	28	81	3	26	5.8

Wetlands consist of hydrologic, soil, vegetation, and wildlife functions and characteristics. Construction and operation of the reservoir would not destroy the hydrologic and soil wetland components. However, construction and operation of the reservoir would destroy the vegetation and wildlife functions and characteristics of wetlands in the reservoir area. Therefore, implementation of the proposed project would cause a reduction in wetland vegetation as well as a change in the relative abundance or frequency of wetland vegetation in the study area. In addition to loss of existing wetland vegetation, approximately 1,070 acres of open water wetland (Lacustrine Littoral Unconsolidated Bottom) would be created.

Table 4.3.6.2 indicates that 486 acres of wetland would be lost due to inundation and construction of facilities under the Dam Site B scenario. This would result in approximately a 26 percent loss of wetlands in the study area. It would cause a substantial reduction of approximately 81 percent in stream wetlands in the study area. In contrast, subirrigated wet meadow would be reduced approximately 25 percent and willow riparian would be reduced by 27 percent. The area of beaver dams would decrease only 3 percent within the study area.

The loss of existing wetlands would constitute a significant impact since wetlands are unique, cover relatively small areas, have low frequencies in the area, and present unique and important wildlife habitat. Wetland vegetation would not pioneer the shoreline of the reservoir because the water level would continually fluctuate. Pioneering vegetation requires relatively stable environmental conditions that would not be provided by a fluctuating water level and shoreline.

Streamflow regulation would alter the flow regime of Rock Creek below the dam. Since the quantity and distribution of streamside vegetation are a function of flow regime, any alteration of this flow would affect the riparian and wetland vegetation. However, the quantity of this change would be minor and not considered significant since flows designed to maintain the channel would prevent riparian vegetation encroachment.

Implementation of Dam Site A would result in approximately 58 fewer acres being lost to inundation than for the Dam Site B including 35 acres of sagebrush association, 9 acres of forest, and 14 acres of wetland. The reduction in wetland losses include 13 acres of willow riparian and 1 acre of stream. Other than the amount of vegetation inundated, the impacts would be essentially the same for both dam sites.

4.3.6.2 Mitigation. Mitigation of wetland losses due to dam construction and reservoir operation could be accomplished in two general ways: (1) creation of new wetlands; or 2) improvement and rehabilitation of existing wetlands in poor condition. Creation of new wetlands would be difficult since areas with conditions required by wetland vegetation are very limited in the general vicinity of the reservoir site and are generally already exploited by wetland vegetation.

Mitigation of wetland values (i.e., wildlife habitat units) by improving and rehabilitating existing wetlands would be more feasible than

creation of new wetlands. Several watershed areas were studied with respect to improving the existing wetland value to mitigate losses at the Rock Creek site. The mitigation plan as presented in Chapter 5 details the measures that would be implemented at these watersheds to improve wetland value and consequently fully mitigate the loss of wetland values.

Portions of the upland areas disturbed by facilities construction and not occupied by the facilities could be revegetated using native and/or adapted species following agency guidelines and recommendations. Successful revegetation would mitigate the loss of the native vegetation at these sites. Control of the establishment of weedy exotic plants should be accomplished following agency guidelines and recommendations if a significant problem develops. A plan for revegetating disturbed sites and controlling the establishment and spread of weed species will be developed for this site. The general points and procedures of the plan are discussed under Water Quality (Section 4.3.3.5) and in Chapter 5.

4.3.6.3. Unavoidable Adverse Impacts. With respect to wetland vegetation and wildlife habitat values associated with the wetlands, the mitigation plan presented in Chapter 5 would totally mitigate the loss of wetlands. Since vegetation would probably take several years to become fully established, there could be a short-term interim loss for these years. From a vegetation perspective, no unavoidable adverse impacts would remain.

4.3.7. Aquatic Biology

4.3.7.1. Anticipated Impacts

Rock Creek. Impacts to Rock Creek and its aquatic community due to dam construction would include siltation, channel changes, loss of cover and general disruption of the stream from the dam site upstream for about a mile. Although these impacts would be major, they would almost all occur in the portion of the stream that would be inundated by the reservoir. Therefore, any loss of habitat or individual fish would occur one or two years sooner than with inundation. Some siltation would undoubtedly occur below the dam site during construction, but due to steep gradients and high velocities it would not settle in the stream until near McCoy. Some brown trout spawning areas near McCoy could be affected negatively by this siltation, but proposed construction methods and siltation prevention measures should prevent any significant impacts.

Inundation of the Rock Creek basin by the proposed reservoir would result in the loss of about five miles of Rock Creek, about two miles of Little Rock Creek, and about a mile each of Shoe and Stocking and Horse creeks. As noted in Chapter 3, the Rock Creek system in the reservoir basin has excellent reproducing populations of brook and brown trout and is stocked with rainbow trout. Biomass estimates of self-sustaining trout were above 30 pounds/acre for all stations. Streams with 20 pounds/acre or

more of self-sustaining wild trout are considered candidates for Wild Trout Waters by the CDOW. Stations on both Rock and Little Rock creeks had over 100 pounds/acre, which included some stocked rainbow trout. Therefore, the self-sustaining trout populations in the portions of Rock Creek and its tributaries that would be inundated by the reservoir are very good.

The populations of trout at Rock Creek are a reflection of the habitat quality available in the system. As discussed briefly in Chapter 3, the Instream Flow Incremental Methodology (IFIM) was used to assess habitat quality. The IFIM uses actual measurements of stream width, depth, velocity and substrate, along with known habitat preferences of fish species to quantify the amount of preferred habitat, or weighted usable area, in a stream. The IFIM analysis indicated that the percent of weighted usable area (WUA) for adult brown trout was about 20 percent during late summer base flow months at the upper Rock Creek stations, which was comparable to recognized excellent trout streams in Colorado. Table 4.3.7.1 shows the amount of WUA per 1000 feet of stream at each of the stations measured for this study, along with the percent of the total stream area represented by WUA. The numbers in this table are primarily useful in comparing different streams and will be discussed again in Chapter 5, Mitigation.

The portion of Rock Creek and its tributaries that would be inundated includes high self-sustaining trout populations and excellent habitat quality. Therefore, the loss of these high quality streams and their fishery resources would be a significant impact.

Rock Creek below the dam would still provide stream habitat. The stream in this area drops rapidly into a canyon. Station R-4 (Table 4.3.7.1), which represents this reach, showed very little habitat for brown trout with the IFIM analysis. Only 3 percent of the available surface area at the station was WUA for adult brown trout. At present, upstream spawning in the vicinity of the proposed dam site probably provides most of the recruitment of trout to this area. The upstream spawning area would be lost by construction of the dam. The IFIM analysis at Station R-4 indicated almost no spawning habitat was available, probably due to low amounts of suitable substrate, smaller cobbles and gravel. Other parts of the canyon have some spawning habitat, but it is limited. Probably few fish move up from the McCoy area due to a fish passage barrier at a railroad crossing in the lower canyon. The culvert under the crossing has a drop of several feet at its lower end and probably is an effective barrier to upstream movement. Therefore, fish populations below the dam and above the railroad crossing, a distance of about 4 air miles, would probably be reduced because of a lack of spawning and recruitment.

Flow changes below the dam were discussed in the Water Resources section. As discussed in that section, daily flows would follow very closely with the mean monthly flows shown in Appendix A. Flows would generally be increased over present levels except during runoff months such as May and June when flows would be reduced. An IFIM analysis of the WUA for adult brown trout under present flow regimes compared to that under proposed future regimes was made at Station R-4. Figure 4.3.7.1 shows the percent that WUA would change with the dam in place by month for a 21 year period of record. Note that during each year except 1977, a drought year,

Table 4.3.7.1. Present available habitat for adult brown trout at IFIM stations during base flow periods: July-October.

Station	Weighted Usable Area (ft^2/1000 ft. stream)	Percent of Available Area
Rock Creek		
#1	3100	20
#2	2500	22
#3	3000	18
#4	480	3
#5	8300	15
Little Rock Creek	750	18
Horse Creek	600	17
Colorado River	17000	18
Blue River	13400	15
Muddy Creek		
#1	6000*	18
#2	8500*	30

*assuming vegetated banks

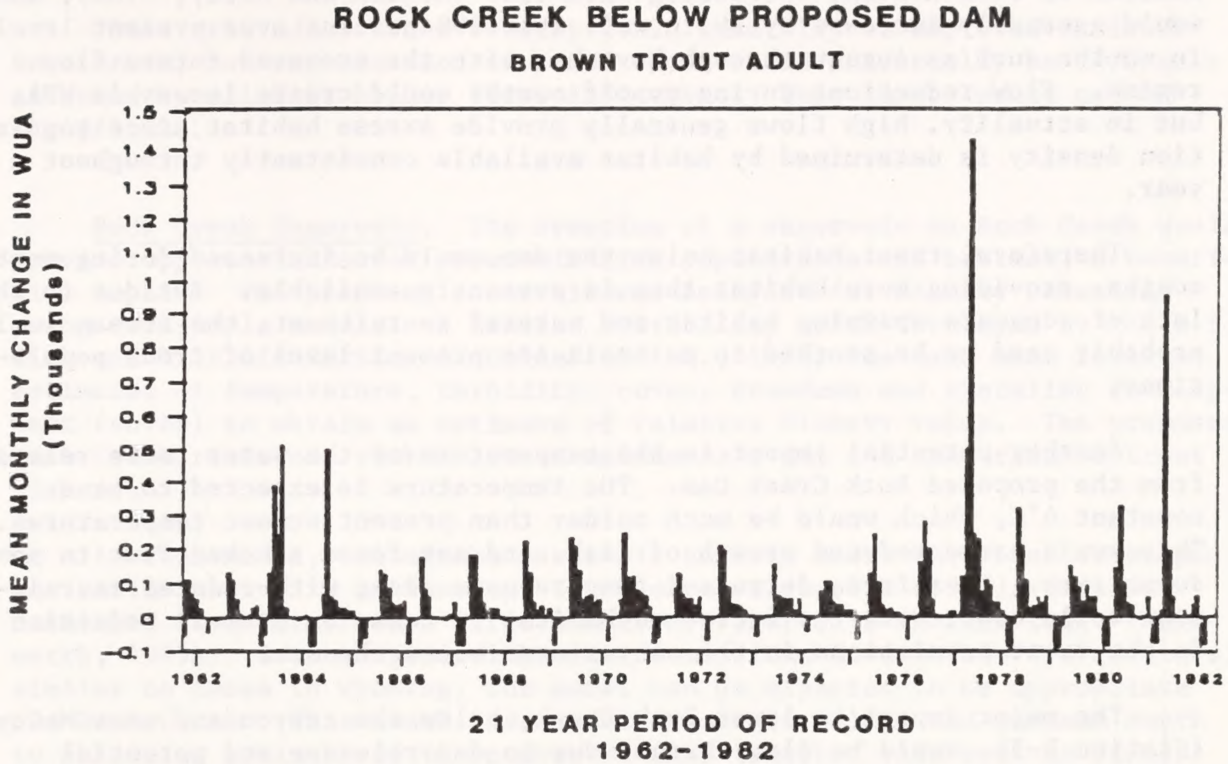


FIGURE 4.3.7.1. Percent change in mean monthly WUA for Rock Creek Station R-4 below the proposed Rock Creek Dam for present flows versus predicted post-impoundment flows.

habitat would be reduced for one or two months. These months are runoff periods of May and June. During all other months of all years habitat would be increased substantially. WUA for adult brown trout at this station is flow driven, increasing with flow (Holden and Hardy, 1986), and would generally increase by 10 to well over 100 percent over present levels in months such as August through November with the proposed future flow regime. Flow reductions during runoff months would create losses in WUA, but in actuality, high flows generally provide excess habitat since population density is determined by habitat available consistently throughout a year.

Therefore, trout habitat below the dam would be increased during most months, providing more habitat than is presently available. But due to the lack of adequate spawning habitat and natural recruitment, the stream would probably need to be stocked to maintain its present level of trout populations.

Another potential impact is the temperature of the water to be released from the proposed Rock Creek Dam. The temperature is expected to be a constant 4°C, which would be much colder than present summer temperatures. This would cause reduced growth of fish, and may force stocked fish to move downstream. Therefore, decreased temperature, along with reduced recruitment would counteract the increased habitat to cause an overall reduction in the trout populations in the canyon area below the dam.

The major impact to lower Rock Creek, below the canyon and near McCoy (Station R-5), would be flow changes due to dam releases and potential temperature effects. Stream flow data for this station consists of only two years data, so comparisons of pre- and post-impoundment flows were not possible. Base flows in this stream section were near 20-30 cfs when the IFIM measurements were taken. Releases from Rock Creek dam would tend to increase most monthly flows except during runoff, much as for Rock Creek Station R-4 as noted above. Information in Section 4.3.3.3 suggests that flows at McCoy may be increased about 50 percent during most years in October, a base flow month. The IFIM analysis for the McCoy Station (R-5) indicated adult brown trout habitat (WUA) increased with flow up to about 90 cfs and then decreased somewhat. Therefore, habitat for adult fish in lower Rock Creek would not be deteriorated by the project, and may well be improved over present conditions. Spawning habitat was quite low at Station R-5 and decreased somewhat with higher flows. Therefore, spawning habitat for brown trout would be expected to be reduced slightly by the increase in flows during October, the primary spawning month. Spawning habitat would occasionally be impacted by too high a release. This would likely have happened in October of 1963 (Appendix A) when 107 cfs would have been released compared to the natural flow of 7 cfs. But such high releases in October have only occurred once in the period of record. Such an uncommon occurrence would not significantly affect the fish population.

As noted in Section 4.3.3.3, flow patterns at McCoy between the October spawning of brown trout and the winter period will be slightly higher but follow a similar pattern to present flows. Therefore, no impacts to spawning and overwintering eggs should occur.

Colder water temperatures are also expected from the dam, but these should moderate before reaching the McCoy area. Also, 4°C is near the temperature at which spawning was observed in upper Rock Creek in 1985.

Therefore, adult trout habitat would generally be improved in lower Rock Creek, but reproduction of brown trout could potentially be adversely affected by slightly higher flows in October. This impact would not be significant.

Rock Creek Reservoir. The creation of a reservoir on Rock Creek would provide opportunities for reservoir fish populations and habitat, a beneficial impact. The proposed reservoir was analyzed for fishery potential using two simple models. A habitat suitability model developed by the U.S. Fish and Wildlife Service (McConnell et al., 1982) was used that involves estimates of temperature, turbidity, cover, drawdown and shoreline development (coves) to obtain an estimate of relative fishery value. The proposed Rock Creek reservoir ranked low to medium as a put and take rainbow trout fishery.

Another model, called the reservoir quality index (RQI) and developed for small reservoirs in Wyoming, involved a regression formula that was developed from data from a large number of reservoirs in that state (Whitworth, 1985). Because general habitat conditions in Colorado are relatively similar to those in Wyoming, the model can be expected to be appropriate for Rock Creek. This model uses total dissolved solids and maximum depth to obtain an estimate of the number of fish (stocked rainbows) or biomass per acre that would be expected to occur in the new reservoir. The model indicated Rock Creek would produce a relatively low amount of trout biomass. Both models, therefore, suggest that the proposed reservoir would not be a high quality fishery. This appears reasonable based on the low nutrient level of the stream and the high elevation of the site.

During the first two to four years, the reservoir would probably produce more fish than indicated by the two models. This is typical of reservoirs in that nutrients are leached into the water from the inundated land, causing a brief but often spectacular increase in nutrients for the food chain, culminating in fast growth of stocked trout. Once these nutrients are used up, the reservoir must rely on the inflowing stream for most of its nutrient input. Also, yearly fluctuations would only be in the 10-15 foot range. This stability in the reservoir should benefit the fishery and perhaps allow a slightly better fishery than projected above. The reservoir would be totally dewatered in dry years, 1977 in the period of record. The fishery would be eliminated and would need to be initiated again. Fig. 4.3.3.5 also indicates that the reservoir would take several years to recover to full volume after a dry year. This would seriously impact the fishery that had developed and suggests a put-and-take fishery would be the best management of the reservoir.

The CDOW has indicated they would probably manage the reservoir with either rainbow or cutthroat stocked as fingerlings or catchables, but the Division has indicated an unwillingness to undertake financial responsibility for stocking. Therefore, the River District has agreed to provide

$10,000 annually for stocking of the reservoir as enhancement. The River District would also support reestablishing the fishery after evacuation of the conservation pool during extreme dry years. If fingerlings were used, the stream would be poisoned before filling the reservoir to rid the area of large numbers of brown trout that would compete with the small stocked trout. Brown trout and brook trout would gradually become established in the reservoir as they would gain access from upstream populations. A kokanee salmon fishery may also be created, although this would probably occur after the reservoir characteristics were better known.

Therefore, the reservoir would provide a low to medium quality fishery of stocked trout, except perhaps for the first two to four years when fish growth could be good and the resultant fishery good, a beneficial impact.

Other Areas. Colorado River - Fig. 4.3.7.2 indicates the percent change in mean monthly WUA for adult brown trout for the Wild Trout Water portion of the Colorado River between Kremmling and the mouth of Rock Creek. This figure shows the change in WUA that would occur between present simulated monthly flows and future simulated flows with the reservoir in place. Habitat generally increased each month of each year except for about four months during the entire 21 year period of record (Fig. 4.3.7.2). Habitat changes would generally be less than 10 percent, but are in the 20-30 percent range three or four months out of the period of record. The habitat changes would be caused by small flow depletions (usually about 5 percent) that would occur during most months. WUA for adult brown trout for the Colorado River decreased with flow (Holden and Hardy, 1986), which indicates that the decrease in flow caused by the project would generally increase the amount of available habitat. The same amount of change would occur with brown trout juvenile and spawning habitat. Since the habitat change is generally less than 10 percent, it is doubtful that the trout population in the Colorado River would change noticeably. Therefore, this would be a beneficial impact, but it would be too small to be significant.

Table 4.3.3.4 shows the changes in flow that would occur in the Colorado River below Rock Creek (Colorado River at Dotsero). These changes would not be expected to alter populations or habitat sufficiently to affect the game or non-game fish in this section, except for the endangered species that are discussed below.

Blue River - Fig. 4.3.7.3 indicates the percent change in mean monthly WUA for adult brown trout for the Gold Medal portion of the Blue River between Green Mountain Reservoir and its mouth. This figure indicates that habitat would be altered less than 10 percent most months during the period of record, but unlike the similar figures for Rock Creek and the Colorado River, both increases and decreases in habitat are common. Holden and Hardy (1986) indicate that WUA in the Blue River increased with flow up to about 300 cfs, and then decreased at higher flows. Appendix B indicates that simulated monthly flows in the Blue River would range from about 200 to about 400 cfs, therefore causing the small increases and decreases in WUA. Monthly changes in brown trout adult habitat of 25 percent or greater would occur 4 times in the 21 year period of record analyzed. Three of

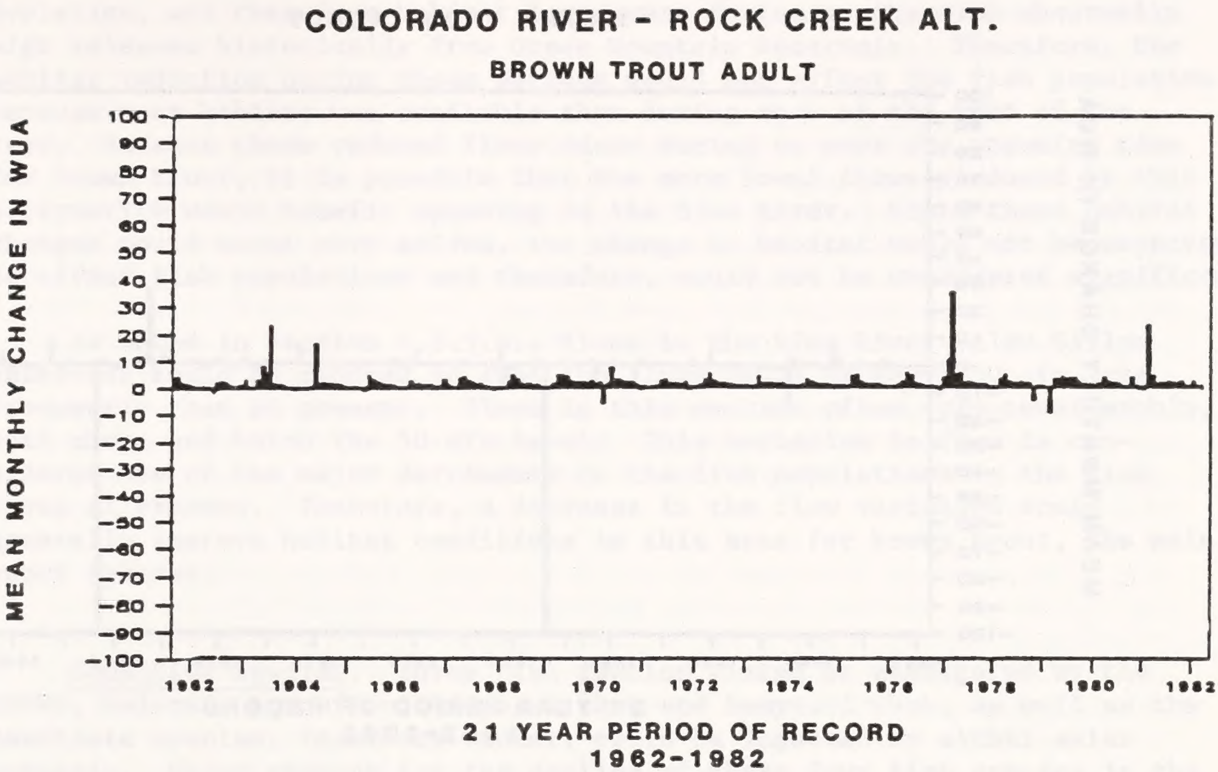


FIGURE 4.3.7.2. Percent change in mean monthly WUA for the IFIM analysis for the Colorado River in Gore Canyon for Rock Creek Reservoir.

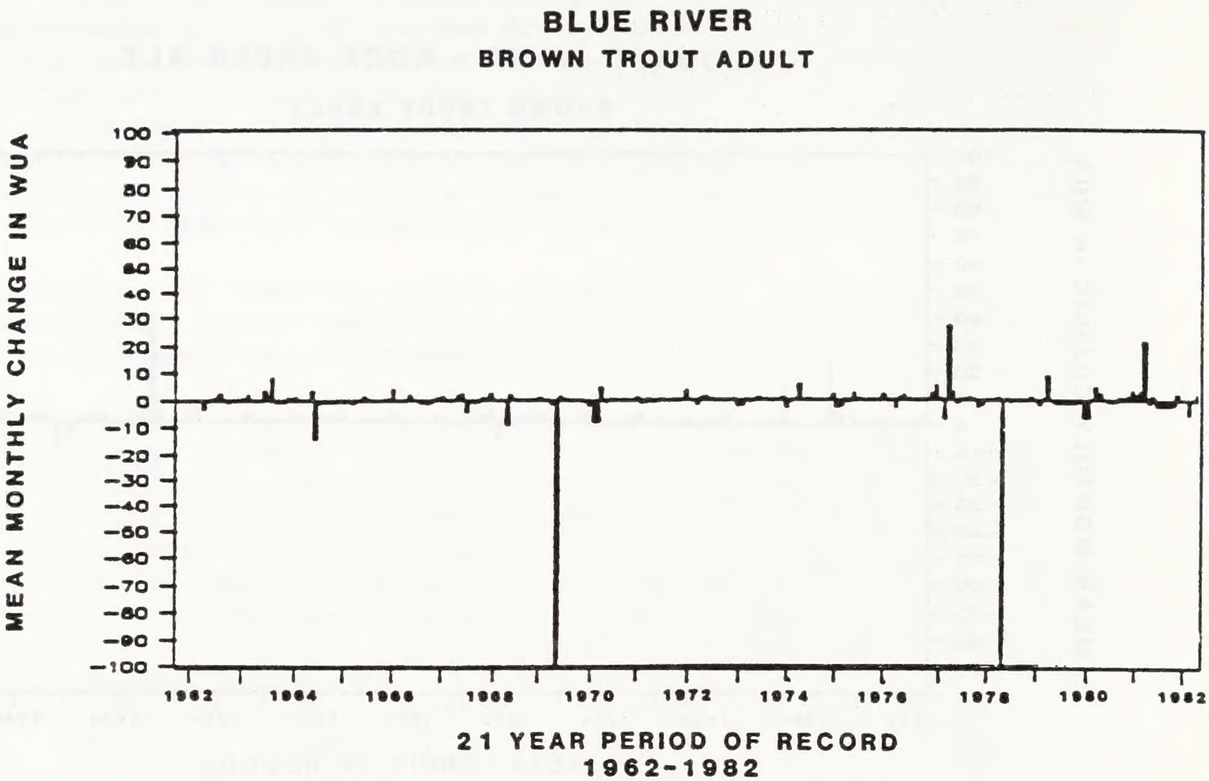


FIGURE 4.3.7.3. **Percent change in mean monthly WUA for the IFIM analysis for the Blue River below Green Mountain Reservoir for Rock Creek Reservoir.**

these months would be decreases in habitat, the other an increase in habitat. All of the times of greatest habitat loss occur in September and October. A review of Appendix B indicates that times of greatest flow depletion, and therefore habitat loss, were during months with abnormally high releases historically from Green Mountain Reservoir. Therefore, the habitat reduction during these periods would not affect the fish population because more habitat was available than during most of the rest of the year. Because these reduced flows occur during or near the spawning time for brown trout, it is possible that the more level flows produced by this alternative would benefit spawning in the Blue River. Since these habitat changes would occur very seldom, the change in habitat would not be expected to affect fish populations and therefore, would not be considered significant.

As noted in Section 4.3.3.4., flows in the Blue River below Dillon Reservoir would be reduced in that the flows would be above 50 cfs less frequently than at present. Flows in this section often vary considerably, both above and below the 50 cfs level. This variation in flow is considered one of the major detriments to the fish populations in the Blue River at present. Therefore, a decrease in the flow variation would generally improve habitat conditions in this area for brown trout, the main sport species.

Sensitive Species. Three fish species listed as endangered by the USFWS, Colorado squawfish, humpback chub and bonytail chub, as well as the candidate species, razorback sucker, could be impacted by either sales scenario. Major reasons for the decline of these four fish species in the past include the loss of habitat due to construction and operation of dams, primarily the Colorado River Storage Project dams in the upper Colorado Basin. Reasons for declines in remaining free-flowing sections are less clear but appear to be related to altered flow due to existing upstream dams and other water development and their effect on reproductive success (Holden 1979, 1980, 1983; Holden and Wick, 1982; USFWS, 1986). The actual mechanism involved with altered flows in lowering reproductive success is not known.

Another complicating problem for the humpback chub is hybridization with the roundtail chub. Most present populations in the Upper Basin appear to be hybridizing (Valdez and Clemmer, 1982). Changes in flow appear to be the major reason for this increased level of hybridization.

Appendix A (Table A.4) shows the depletions that would occur due to the Denver Metro Lease sales scenario in the Colorado River below Rock Creek. Depletions greater than 6 percent of simulated flows only occur once in May of 1982, and that was only 7 percent. Therefore, by itself, Rock Creek reservoir would not be expected to negatively impact the rare fish since flow changes would be very small.

Alternative Dam Site A. Dam Site A is located upstream about a half mile from Site B. Construction at this site would inundate less of the excellent trout habitat in Rock Creek. It would also provide for spawning areas below the dam that would not be available with Site B. A considerably better tailwater fishery could be established with Dam Site A and the

negative impacts would be reduced somewhat, but the reservoir would still inundate over eight miles of excellent trout stream. Therefore, Dam Site A would still create a significant adverse impact to aquatic biology.

4.3.7.2. Mitigation. The loss of nine miles of excellent trout stream in the Rock Creek drainage and the reduction of the brown trout population below the dam are the adverse impacts that need to be considered for mitigation. As discussed in the Vegetation section, a mitigation site along Egeria Creek, just a few miles west of Rock Creek, appears to be a reasonable mitigation site for wetlands. Egeria Creek in this area has relatively few trout and its habitat is in very poor condition due to grazing and haying up to its banks. This site appears to be a good potential mitigation site since it needs considerable improvement and about 10 miles of the stream may be available. Based on preliminary information, it is expected that Egeria Creek would not replace all of the aquatic resource values lost at Rock Creek. See Chapter 5 for more information on the proposed mitigation.

Mitigation of the loss to the brown trout in Rock Creek below the dam would involve monitoring to see if reproduction is limiting and then stocking the area to maintain a fishable resource if needed. Not all of the impact would be mitigated if stocking is required since the self-sustaining population would be lost. See Chapter 5 for more details on the proposed mitigation.

4.3.7.3. Unavoidable Adverse Impacts. A portion of the loss of the high quality habitat in the reservoir basin and a portion of the loss of the self-sustaining population below the dam would remain as unavoidable adverse impacts.

4.3.8. Wildlife

4.3.8.1. Anticipated Impacts

General Wildlife. Anticipated primary impacts to wildlife occurring as a result of developing the proposed reservoir at the Rock Creek site fall into three general categories: 1) disruption of wildlife use of the area during construction and operation of the reservoir; 2) direct loss of existing habitat by inundation; and 3) creation of lacustrine habitat and establishing populations of its associated species.

Impacts Associated with Construction and Operation. Construction activities associated with the dam and relocation of a transmission line would disturb several wildlife species during the two years of construction. Elk calving and mule deer fawning could be disturbed but relatively few individuals of each species use the general dam site area and the impact would be very short term.

Since big game, especially elk, are sensitive to human disturbance, the increased use of the area during and after construction would likely inhibit foraging in the remaining non-forested habitat within the study area. This would be especially true as the reservoir fills and the projected visitation of the reservoir is achieved (175,000 visitor days). Disturbance is expected to be greatest near the proposed campground and to radiate out from that area. Therefore, the west side of the reservoir and surrounding areas would be most affected. Use of motorized vehicles (motorcycles, ATVs, etc.) would cause the most disturbance due to noise and also would affect the largest area due to mobility. This disturbance could adversely affect elk, deer, and other wildlife use of the forested areas on the west side of the reservoir.

The disturbance factor would also be increased by the upgrading and new construction of access roads for the reservoir. Roads are known to affect elk habitat quality (Lyons, 1984). The pre-project density for the study area is 0.653 miles of road per square mile compared to 0.681 following construction. Although the change in overall road density is minimal, establishing new roads in previously undisturbed areas would impact ungulates; however, the number of animals using the area is low and this increased access would not be expected by itself to significantly impact big game during summer use and calving/fawning within the area of concern. There may be some effect on use of the traditional elk and deer migration corridors through the study area by the proposed campgrounds. These effects may be attributable to a possible increase in late-fall camping during the hunting season or early snowmobile activity.

Moose that were reintroduced into the Routt National Forest currently use the area of concern lightly because suitable habitat exists elsewhere throughout their range and they are at very low numbers. Construction and operational activities would not affect this species directly at this time, but may inhibit moose use of the area in the future.

Relocation of the power transmission line would impact about 8.7 acres of wildlife habitat, primarily forested types. This would adversely affect forest dwelling species and provide for increased access and disturbance. There would be a positive effect for species requiring forest openings and edge habitat. Neither impact would be significant by itself.

Impacts Associated with Inundation. The acreages of habitat inundated by the proposed reservoir (Dam Sites A and B) and their relation to the project study area were presented in the Vegetation section (Tables 4.3.6.1 and 4.3.6.2).

The loss of the 486 acres of wetland habitats described in the Vegetation section would be a significant impact. Inundation would cause a

permanent loss of habitat used by waterfowl, passerines, other avian species, aquatic furbearers and other wildlife. Riparian habitat is especially important. In Colorado, wildlife utilize riparian habitats disproportionately more, both in terms of species numbers and densities, than any other habitat type primarily due to the high edge to area ratio (Hoover and Wills, 1984).

Loss of 1,086 acres of non-forested wildlife habitat and associated general wildlife values would be considered a significant impact because of the limited quantity of non-forest habitat types that occur in the Routt National Forest (USDA/FS, 1983). Elk, mule deer, black bear, beaver, coyotes, red fox, small mammals, waterfowl, and many species of passerine birds would be impacted because they derive part or all of their life requisites from non-forested habitats. A loss of potential moose habitat is likely.

Wildlife values for the acreages lost through reservoir development were analyzed with Habitat Evaluation Procedures (HEP) analysis. Habitat Units (HU's) were derived by first determining the Habitat Suitability Index (HSI) for a given area and species. The species selected are taken to be indicators of the habitat parameters that are deemed important and do not by themselves necessarily reflect a value. The HSI was multiplied by the number of acres of habitat for the indicator species within the area proposed for inundation to obtain HU's (Table 4.3.8.1). A separate report (Pekins and Hugie, 1986) details the HEP conducted at Rock Creek.

Table 4.3.8.1
Loss of Wildlife Values Due to Inundation of Rock Creek

Indicator species	Associated habitat type	Habitat units affected
Elk	Sub-irrigated meadow Willow riparian Sagebrush association	655
Beaver	Willow riparian	188
Yellow warbler	Willow riparian	148
Blue grouse	Sagebrush association	444
Brewer's sparrow	Sagebrush association	516

Table 4.3.8.2 summarizes another method of quantifying habitat lost through reservoir development. This is the Habitat Capability Model (HABCAP) developed by the USFS (Hoover and Wills, 1984). A habitat value is assigned to cover types and structural stages based on the capability of

Table 4.3.8.2
USFS Habitat Capability Evaluation
for the Rock Creek Study Area

Indicator species	Season	HABCAP Index with no action	HABCAP Index with reservoir
Mule deer	Summer	0.55	0.54
	Winter	0.28	0.31
Elk	Summer	0.40	0.38
	Winter	0.39	0.36
Moose	Yr-rnd	0.67	0.67
Pine marten	Yr-rnd	0.76	0.77
Goshawk	Summer	0.65	0.65
	Winter	0.61	0.61
Blue grouse	Summer	0.21	0.21
	Winter	0.11	0.12
Warbling vireo	Summer	0.22	0.23
Wilson's warbler	Summer	0.18	0.17
Hairy woodpecker	Yr-rnd	0.63	0.66
Northern three-toed woodpecker	Yr-rnd	0.19	0.20

those types and stages to fulfill the life needs of a species. This gives an estimate of the habitat capability for the species within the area. Ten forest indicator species for fourth order drainages were analyzed to determine effect of inundation on the forest habitat. Although the change in the HABCAP index is small, species such as deer and elk do show a reduced habitat capability. Other species, such as the warbling verio and the hairy woodpecker would show an increased habitat capability.

Loss of small mammals due to inundation could affect the local prey base for raptors; however, since these prey species are common and prolific breeders, and raptors are highly mobile, loss of prey would not significantly impact resident birds.

The loss of elk and mule deer summer range due to inundation would be adverse but not significant by itself because relatively few elk and mule deer utilize the reservoir area because of the disturbance of fishermen, campers and the availability of similar or better habitat that is nearby and not as subject to disturbance.

In addition, the reservoir may pose a physical barrier to traditional movement corridors, both daily and during migratory periods. Such a barrier would not be considered significant for daily movement of big game because alternative routes exist that are currently used and would remain unobstructed.

The shoreline itself and reservoir ice during the fall may produce adverse impacts to fall migrations of elk. The northern and central shorelines could provide a boundary to "drive" big game against and thereby increase legal and illegal mortality. Also, big game moving across the frozen reservoir may break through or slip on the ice, thereby causing injury or death. The extent of this impact cannot be predicted; however, this impact could be significant.

Creation of Lacustrine Habitat. Creation of lacustrine habitat would likely increase waterfowl use of the area as a stopover during migration which would be a positive impact. Fluctuations in water levels and low nutrient levels would probably combine to preclude establishment of shoreline vegetation necessary for foraging and perhaps nesting waterfowl.

Secondary Impacts. Secondary impacts would be caused by increased recreational development on private lands in the area, notably the Long Park area. This disturbance could reduce the use of the area by many species of wildlife including big game, raptors, and other avian species. It is not possible to predict the level of development that may occur and therefore the level of impact to wildlife. Therefore, development of private lands that would be spurred on by the Rock Creek Reservoir could cause adverse impacts to wildlife.

Sensitive Species. There are no known resident or breeding populations of state or federally threatened or endangered species in the study area. Therefore, no significant impacts on any sensitive species would occur as a result of construction and operation of the proposed reservoir. The creation of a large body of open water may attract bald eagles (federally endangered) because they commonly forage on fish. Also the stream below the proposed dam would likely remain open longer into the fall and provide foraging habitat.

Impact Summary. In summary, the loss of 1,086 acres of non-forested general wildlife habitat and its associated wildlife values by inundation, particularly the 486 acres of wetland habitat, would be significant. The cumulative loss of habitat due to inundation and construction, together with the disturbance due to increased visitation and use of the area, would affect a substantial area, probably several thousand acres of habitat. This would result in animals moving out of this area but it is suspected that sufficient summer habitat exists in surrounding areas that overall population numbers should not be reduced. The impact of reservoir ice on elk is a potentially significant impact.

4.3.8.2 Mitigation. Significant adverse impacts to wildlife have been determined to be limited to the loss of the wildlife values associated with 1,086 acres of general non-forested habitats and 486 acres of wetland habitats, and loss of habitat capability due to disturbance and habitat loss. Losses of individual big game animals attributable to increased mortality through driving them against the reservoir boundary or ice hazards could potentially become high enough to be considered significant.

The magnitudes of the significant impacts associated with loss of wildlife values noted above were quantified through the use of the Habitat Evaluation Procedure (HEP) in terms of Habitat Units (HUs). The methodology used was as described by the USDI/FWS (1980) and modified by Pekins and Hugie (1986). Replacement of the lost HUs would be accomplished by acquiring land with the appropriate habitat potential to replace the wildlife values lost through development and operation of the Rock Creek Reservoir. A management plan would be devised to develop this potential and retrieve the associated wildlife values sacrificed at Rock Creek. A review of potential sites in the general area and several onsite inspections have delineated a 2,110-acre area of Egeria Creek as possessing the necessary factors to accomplish this goal. Section 5.1.5 details the mitigation procedures necessary to accomplish the goal of replacing the lost wildlife values.

Loss of habitat capability due to disturbance and habitat loss could be partially mitigated through a well enforced Forest Service restriction on ATV use of surrounding forested areas except on existing roads. This would reduce but not eliminate the loss of habitat capability.

In order to determine if big game losses due to migration over the iced reservoir significantly affects the local big game populations, a monitoring program would be conducted by the CDOW during migration seasons following inundation of the reservoir. If losses are deemed to be significant, appropriate fencing will be constructed along the reservoir perimeter to eliminate big game access to the inundated basin.

4.3.8.3 Unavoidable Adverse Impacts. Unavoidable adverse impacts would only include the loss of habitat capability due to disturbance and habitat loss. Proposed mitigation would not alleviate all of this impact. Population numbers would not be reduced.

4.3.9. Land Use Plans

4.3.9.1. Anticipated Impacts. The proposed reservoir would inundate 805 acres of National Forest System land, 191 acres of State land, and 74 acres of private land. The private land would be lost for future uses to the landowner.

By Regulation (Title 36 Code of Federal Regulations [CFR] Part 219.10-[e]), all projects proposed on National Forest System lands must conform to the direction, standards and guidelines set forth in the Forest Plan;

however, modifications may be made in the area direction, management prescriptions and other aspects of the Forest Plan in order to accommodate new developments and changing social needs. Construction of the CRWCD's proposed reservoir would require some modification of the Routt National Forest Land and Resource Management Plan. These changes must be made through a process of amendment which conforms to Title 26 CFR Part 219.10-(f).

The amendments described in this section are formulated to cause the alternative to be consistent with the Forest Plan. All future permits, rights-of-way and easements related to the proposed project will incorporate appropriate requirements and mitigation measures necessary to ensure consistency with direction, standards and guidelines of the Forest Plan as amended, and with state and Federal laws and regulations. None of these proposed amendments are significant as defined by 36 CFR 219.10(f).

Changes in Goals and Objectives. None of the proposed alternatives would require changes in goals of the Forest Plan. The Forest Plan provides for water storage, as needed, when anticipated benefits from the project equal or exceed existing benefits from the area affected. Objectives of the Forest Plan are described in terms of specific levels of goods and services expected to occur over time, given the management activity planned. Changes in planned production levels for goods and services would occur as a result of the proposed alternative.

Changes in Forest Direction. The Forest Direction section of the Forest Plan specifies environmental quality conditions and management requirements to ensure conditions be maintained while implementing practices on the Forest. Forest direction would be modified to include detailed monitoring plans for: erosion control, water quality, fisheries productivity, stream channel stability, recreation opportunity maintenance, and indigenous wildlife species habitat maintenance. These detailed monitoring plans would be developed by the proponent and approved by the Forest Service as part of project design and completed prior to construction activities. The proponent would be required to make an annual submission of an evaluation report, summarizing findings of monitoring activities.

Changes in Management Area Direction. The Routt Forest Plan would be amended to include the proposed reservoir area and a buffer around it in management prescription 2B (emphasis on rural and roaded natural recreation opportunities). This amendment would displace portions of existing management prescriptions 3A, 4B, and 9B (Figure 3.10.2). Table 4.3.9.1 displays these changes in acreages. The Management Area Summary (Forest Plan, Chapter III, pages III-81) would be amended to reflect this change in acreage. Due to visual impacts of a dam structure and associated access road, the guideline for visual resource management activity in prescription 2B would be amended as follows: "Do not exceed an Adopted Visual Quality Objective (VQO) of Partial Retention. However, within that part of the project area where the dam structure and access road is located, visual impacts would exceed a VQO of partial retention."

Table 4.3.9.1
Changes in Allocation of Management
Prescription on the Routt National Forest Resulting
from the Proposed Rock Creek Reservoir Development

Management prescription	Additional acres	Reduction in acres	Percent change
2B	2545		19.7
3A		163	.1
4B		953	1.6
9B		2545	2.2

The 3A prescription is currently allocated to that part of the reservoir project containing the dam structure, a portion of the reservoir surface area, and access road to the dam structure. The 4B prescription is currently allocated to that portion of the reservoir project containing facility development for day use and overnight camping. The 9B prescription is currently allocated to a significant portion of the proposed reservoir south of the current campground (including the Horse Creek drainage) and the alternative Dam Site A. The proposed change in management prescription of these areas to 2B was based on several conflicts in proposed activities related to the reservoir that would conflict with current management prescriptions. Conflicts with 3B involved motorized vehicle use; the wildlife habitat guidelines for a 4B prescription would be impacted by road construction and general habitat capability; silvicultural practices prescribed in 9B would have exceeded visual impact standards.

Potential downstream impacts on channel maintenance and stream degradation would be mitigated as discussed in the Surface Water Resources (Section 4.3.3) and not conflict with standards delineated in the Forest Plan (USFS, 1983).

4.3.9.2. Mitigation. The private landowner would have to be compensated for the economic loss of the 74 acres that would be inundated.

4.3.9.3. Unavoidable Adverse Impacts. The inundation of 1072 acres of land is an unavoidable adverse impact as existing land uses would essentially be eliminated.

4.3.10. Grazing

4.3.10.1. Anticipated Impacts. The impacts to grazing within the Rock Creek study area were defined as actions that would decrease the

carrying capacity (expressed in AUMs) of a given domestic livestock allotment directly through forage loss. A loss of 10 percent or more of the allotment's carrying capacity was considered significant. Impacts associated with decreased carrying capacity of a given allotment include: 1) direct permanent loss of forage within the area to be inundated; 2) loss of grazing opportunity associated with fencing for protection of recreation sites, access routes, the dam site proper and erosion control features; and 3) increased competition for forage with wild ungulates using the same area.

A summary of the potential impacts on each of the three allotments affected by the proposed project is presented in Table 4.3.10.1. The most

Table 4.3.10.1
Summary of Impacts to Grazing Allotments
Near the Proposed Rock Creek Reservoir Site

Allotment type 1/	Pre-project capacity 2/	Losses 3/ Inundation	Losses 3/ Other	Post-project capacity	Net change 4/
Horse Creek					
C & H	678	18	0	660	2.7
Blacktail Creek					
C & H	1333.2	142	2	1189.2	10.8
Cobberly-Maudlin					
C & H	1357	77	28	1252	7.7

1/ C = cattle, H = horses

2/ Based on USFS estimation, Routt National Forest, Yampa District

3/ Weighted according to carrying capacity

4/ Percent

important impact would be to the Blacktail Creek allotment where 144 AUMs or roughly 11 percent of the allotment's capacity would be lost. In the Cobberly-Maudlin allotment 106 AUMs or about 8 percent of the allotment's capacity would be lost. The Horse Creek allotment would lose about 18 AUMs or about 3 percent of its capacity. The loss to the Blacktail allotment is considered significant.

It is anticipated that fences, gates and cattle guards would be built or replaced where needed during normal construction procedures. Therefore, the USFS and permittees would not be subject to increased management or capital costs in the allotments for these expenses.

4.3.10.2. Mitigation. The significant change in capacity for the Blacktail allotment would require mitigation. There are two potential ways of mitigating the loss of AUMs:

- The permittee could acquire about 120 acres of private property. Most of this would be inundated but the remaining ± 50 acres would be available for grazing.
- Range carrying capacity could be increased by implementing various range improvement techniques within the remainder of the allotment.

4.3.10.3. Unavoidable Adverse Impacts. None

4.3.11. Visual Resources

4.3.11.1. Anticipated Impacts. Construction of the Rock Creek dam would result in a number of long and short-term visual effects. The 710 foot long dam and related permanent structures would have substantial long-term visual impacts. The form, color, texture and mass of the dam would be foreign to the characteristic landscape, and would interrupt the lineal orientation of lower Rock Creek Canyon. All aspects of the dam proper would exceed the Partial Retention Adopted Visual Quality Objective (VQO) established for the area by the USFS in both the short and long term. However, these impacts would be most evident from below the dam or from uplands to the south, areas frequented by limited numbers of dispersed recreationists.

Numerous short-term visual impacts would be associated with dam construction, including upstream and downstream coffer dams, stream diversions, borrow sites, aggregate stockpiles, processing plant, batch plant, and associated structures. These would result in the introduction of structures with an industrial appearance as well as substantial ground surface disturbance due to removal of vegetation and overburden. The resulting contrasts in form, texture, and particularly, color would exceed standards permitted in a USFS VQO zone designated for partial retention. However, the sensitivity level would be low due to limited visual access and screening inherent in adjacent topography and vegetation. In the long term, all visual evidence of construction activities and structures upstream of the dam would be eliminated by water impoundment.

Relocation of the 138 KV transmission line would result in several short and long-term visual impacts, the most severe being the impact associated with the western 1.25 miles of the relocated line in a Retention VQO. Even though the level of sensitivity for this section would be high

due to the line's proximity to Highway 134 and the reservoir, the section of relocated line accessible to view would be similar to the existing line, and would therefore have similar visual impacts. In addition, the presence of the water body should attract viewers' attention away from this section of the transmission line. The section of transmission line from 0.1 miles east of Little Rock Creek to Rock Creek would also create impacts. Although this section would be screened from most viewers, required tree removal, ROW maintenance and the proposed straight alignment would produce a visible line that would exceed Partial Retention standards. In addition, the eastern 1.0 miles of relocated line would traverse an open sagebrush/grassland meadow adjacent to Jolley Creek in an area that would be visible to boaters on the eastern 1/3 of the reservoir. This would constitute a visual intrusion that would contrast with the characteristic landscape.

Additional visual impacts would result from road development and relocation. Relocation of a 0.5 mile section of Highway 134 would require cutting and filling across an open sagebrush/grassland sideslope, producing constrasts visible to both motorists and boaters on the reservoir. Contrasts would be in excess of the Retention standards established for this area, but impacts of the relocated road would be similar to those associated with the existing alignment. Small segments of the dam access road would be highly visible to both motorists and boaters. In the short term, the effects of grading, cutting and filling on some road sections would exceed the Retention and Partial Retention VQO established for the area. However, much of the route would follow existing roads, and some segments would be effectively screened from areas frequented by the public. Consequently, the site disturbances associated with access road construction, which in several locations would exceed Partial Retention standards, would seldom be seen even by dispersed recreationists in the area.

Assessment of the visual impacts of recreation facilities developed adjacent to the reservoir was based on available conceptual designs of the campground and day-use facilities, since no detailed design has been prepared. Road construction for the campground would require removal of vegetation from the sagebrush/grassland complex and a limited number of lodgepole pine along the ROW, resulting in lines, colors and textures which would contrast with the characteristic landscape. However, the proposed curvilinear road alignment and limited visibility of the road and campground facilities would limit visual impacts and would be in compliance with the Partial Retention VQO standard for the area. The boat launch ramp and associated parking would produce contrasts in excess of the Partial Retention VQO, but would be visible from only a few locations, and could be in compliance if appropriate mitigation measures were taken. Construction of the picnic area would result in minor site disturbance which would be in compliance with the Partial Retention VQO.

The Rock Creek reservoir impoundment would flood 1,070 acres of sagebrush/grassland, meadow and sub-irrigated riparian vegetation. With the exception of the dam area, the reservoir pool would be natural in appearance, conforming to the enclosing topography. However, significant changes in form, line, color, texture, size and pattern resulting from the loss of the stream habitat caused by water impoundment would exceed the Retention, Partial Retention, and Limited Area of Modification VQO established for the area. Further visual degradation may result from beaching

and exposure of red-brown soils on shoreline sections subject to erosion by wave action. As water is withdrawn from the reservoir, visual contrast would increase due to increased exposure of mud and gravel flats around the reservoir shoreline, particularly along Little Rock Creek adjacent to Highway 134, an area of high visual sensitivity. Annual fluctuations would be moderate (8-20 feet), so visual contrast would be evident, especially where the gravelly nature of area soils would produce an exposed beach. In addition, the impounded body of water would provide a visually powerful and attractive landscape element which would increase the potential for high scenic quality (USDA/FS, 1974). The exception to this situation would be during and immediately after an extreme dry period such as 1977. The reservoir would be essentially dry and then require several years to refill (Fig. 4.3.3.6). During this period, the exposed reservoir bed would create a significant exceedance of the VQO of partial retention.

Dam Site A. The visual impacts of a dam constructed at the Site A location would be essentially the same as those associated with Site B. The major difference would be preservation of 3,000 feet of meandering stream below the dam. Although this section is of high visual quality, it would be screened from view by the dam and not visually accessible to most recreationists.

Impact Summary. Visual impacts associated with construction and operation of the Rock Creek dam and reservoir would exceed Forest Service VQO for the area. Otherwise, impacts would not be considered significant, since the reservoir would add to the present high visual quality of the area, except during periods of substantial drawdown, such as 1977.

4.3.11.2. Mitigation. None.

4.3.11.3. Unavoidable Adverse Impacts. The VQO of partial retention would be exceeded by the dam and the reservoir during extreme dry periods.

4.3.12. Recreation Resources

4.3.12.1. Anticipated Impacts. The most obvious adverse recreational impact of dam and reservoir development at the Rock Creek site would be the elimination of all current recreation activities associated with the stream and meadow area within the reservoir basin. As was discussed in Section 3.13.1, this area currently attracts substantial summertime recreation use, due largely to the presence of an easily accessed, high quality trout fishing resource in this section of Rock Creek. A recreational assessment of the fishery was made that indicated about 2000 visitor days per summer were spent primarily fishing on Rock Creek in the reservoir basin. The proposed dam site would almost totally innundate the section of the stream between Highway 134 and the steep canyon section, eliminating the stream fishing recreation opportunities associated with this area. Given the

relative scarcity of other nearby stream fishing resources that are of similar quality and accessibility, a significant loss of recreational resources and opportunities would result.

In addition, construction of the reservoir would necessitate relocation of the historic Stage Stop building away from its original setting, and would also inundate the nearby iron springs. Both of these are unique to the area and attract some recreational visitation. The option of recording the Stage Stop site and destroying the structure would cause the loss of all future recreation and cultural use associated with the Stage Stop. This would be an adverse impact.

No other significant onsite adverse impacts would be expected to occur. Because the reservoir would not significantly affect overall populations of game species, no adverse effects on hunting are anticipated, although other reservoir-related recreation activity and increased human presence could cause some shifts in the habits and concentrations of game animals, thereby affecting the degree of success among hunters using particular areas. Offsite adverse impacts are also not anticipated to be significant. The potential for increased off-site recreation is high since the number of people expected to use the campground is large. It is expected that many of these people will use the surrounding forest lands for hiking, ORV use, and other dispersed types of recreation.

Reservoir operations would result in limited changes in the flow of the Colorado River (see Section 4.3.3.4), but these alone would not significantly impact river floating or fishing opportunities, particularly in comparison to simulated baseline conditions that indicate that river flows will be insufficient to maintain quality floating even without the development of this reservoir. As shown in Appendix A, flows in Gore Canyon during the summer floatboating season would generally only be reduced by 20-40 cfs and would not affect present flow levels sufficiently to impact boating.

Development of the Rock Creek reservoir would also result in a number of potentially positive effects on recreation resources and opportunities. The reservoir would provide a visually attractive lake recreation setting, that would provide opportunities for fishing, boating and sailing, camping, and various other shoreline recreation uses. Although the quality of the lake fishery would be only low to medium (see Section 4.3.7), fishing use would be likely to attract substantial visitation, as would general boating use. Water contact uses such as swimming, water skiing, and windsurfing would probably be limited, due to the relatively high elevation of the site and the cold water temperatures that would exist.

Planned recreation developments would include a 50-unit Forest Service campground, with a potential for expansion to add 20 more units at a later date. Also planned are a day-use picnic area and boat launching ramp near the campground, and parking and toilets at the upper end of the reservoir (see Section 2.4.2). Little or no private development in the immediate reservoir area would be expected, since virtually all of the land surrounding the reservoir basin is controlled by the Forest Service. However, development of recreation-related businesses in nearby towns as well as off-site land development may result from the increased recreation activity attracted by the reservoir and its facilities.

A recreation demand study conducted in 1985 suggests that in 1990 visitation to the Rock Creek reservoir would involve roughly 250,000 recreation visitor days (RVDs, as defined by the Forest Service, one RVD involves one person engaged in a recreation activity for 12 hours, or 2 persons for 6 hours apiece, etc.). Visitation would increase to an estimated level of about 300,000 RVD's by 2010. These estimates appear to be high, because they are roughly equal to the level of current visitation to Steamboat Lake, where both public and private development is much more extensive than would occur at the Rock Creek Reservoir. Although facility developments other than campgrounds and boat ramps undoubtably affect reservoir visitation, no adequate or comparable data on private development levels or development potential were available for the reservoir recreation sites incorporated into the demand analysis models. It would seem reasonable to assume that because there would be little or no potential for lake-adjacent private development at Rock Creek, annual visitation would, in the near term, more likely be in the range of 175,000 to 200,000 visitor days. Even so, this indicates that the Rock Creek reservoir would attract considerable recreation use.

Visitation during and immediately after extreme dry periods such as 1977 (Fig. 4.3.3.6) would drop dramatically due to reservoir drawdown and lose of the fishery. Visitation would build up as the reservoir filled and stabilized.

To a considerable extent this visitation would involve a redistribution of recreation use from other areas. For example, a portion of visitation that currently goes to Steamboat Lake north of Steamboat Springs would be drawn off to the Rock Creek Reservoir, due in part to its location nearer to Denver and other Front Range locations. It is also likely that visitation that currently takes place at the existing campgrounds in the Rock Creek vicinity would gravitate to the new campground developed at the reservoir, with the older campgrounds becoming essentially "overflow" areas. Some additional recreation demand would be generated, however, due both to the recreation opportunities afforded by the reservoir and its facilities and the accessibility afforded by its location adjacent to a major highway. It is likely that this net increase would be a relatively small portion of the total visitation. In any event, the levels of visitation projected for the reservoir and campground facilities would be likely to generate demands for recreation and tourism-related developments in other nearby areas, such as service-oriented businesses in Toponas, Yampa and Kremmling, and perhaps recreation property development in the Long Park area. To the extent that such development would occur, it would provide for a more even balance between winter and summer tourism-related business activity in Routt County.

As noted in Section 4.3.3.4, flows in the Blue River below Dillon Reservoir would be reduced, but the magnitude and frequency of the reduction cannot be quantified. A reduction in flows would reduce the amount of time the river would be acceptable for floatboating. Therefore an adverse impact to floatboating could occur, although it cannot be quantified. A similar impact was noted in the Metropolitan Denver Water Supply EIS (U.S. Army Corps of Engineers, 1986) and it was considered significant. Since releases from Dillon related to Rock Creek would be

much less in frequency and magnitude than the Denver releases, the Rock Creek impacts would not be significant; but it may add cumulatively to the significant impact of Denver.

In summary, development of a dam and reservoir at Rock Creek would result in significant adverse recreational impacts due to the elimination of a heavily used, high-quality stream fishing area. Negative impacts would also result from the innundation of the historic Stage Stop location although relocation of the Stage Stop building would mitigate some of the impact. At the same time, reservoir development would create new lake recreation opportunities and facilities which would attract very substantial recreation visitation to the area, in turn contributing to some expansion of area recreation and tourism developments. Visitation would drop off during and immediately following an extreme dry year drawdown.

Development of a dam at the alternative Site A (upstream) location would preserve a very short section of this stream fishery, but otherwise would have similarly adverse impacts on recreational stream fishing opportunities.

4.3.12.2. Mitigation. Relocation of the historic Stage Stop building would partially mitigate the effect of site innundation, although the building would be removed from its original historic and environmental context. The loss of the stream fishery impacts would be partially mitigated by the development of a fishery at Egeria Creek as discussed in the Aquatic Biology section and Chapter 5. It is doubtful that Egeria Creek would replace all of the stream fishing opportunities that would be lost at Rock Creek.

4.3.12.3. Unavoidable Adverse Impacts. Loss of the recreation resource provided by the Rock Creek stream fishery could probably not be totally mitigated, leaving an unavoidable adverse impact. Loss of some floatboating below Dillon Reservoir on the Blue River would also be unavoidable.

4.3.13. Cultural Resources

4.3.13.1. Anticipated Impacts. Prehistoric and historic properties could be affected as a result of construction activities related to dam construction, realignment of existing features such as Highway 134 or the transmission line and inundation. Potential future adverse impacts to resources could also result from visitor or recreational use of the reservoir. At present, the total number of cultural resources and their significance is unknown because intensive cultural resource identification and evaluation studies have not been conducted. Based solely on the known information, it is possible to delineate some potential impacts.

Of the cultural resource properties that have been previously recorded, at least seven sites, including the Rock Creek stage station, would be

inundated at the maximum reservoir level. Six of these sites are prehistoric lithic scatters that have not been fully evaluated for National Register of Historic Places (NRHP) eligibility. The Rock Creek stage station is listed on the NRHP; however, the existing level of documentation for both the structure and the surrounding site is minimal. No known sites are located at the site of the dam or other related construction features, but one prehistoric lithic scatter is near the proposed highway realignment route and three other prehistoric lithic scatters are near the proposed transmission line relocation.

Moving the Stage Stop to a new location and inventorying the site would save both the structure and its historical value. Demolishing the Stage Stop or recording the site and flooding it would preserve its historical value but not the structure itself. From a cultural resource standpoint, both options would be acceptable and both would create no significant impact.

Due to the large number of sites identified with little intensive study, the potential for additional significant sites in the affected areas is high. Therefore, due to impacts on important known, as well as probable unknown sites, impacts to cultural resources would be considered significant.

4.3.13.2. <u>Mitigation</u>. In order to fully address the potential impacts to cultural resources at the Rock Creek site, further intensive cultural resources inventory would be required for both the reservoir and adjacent areas. This work would also have to address NRHP evaluations for previously recorded resources such as the Stage Stop. Any significant sites located within the area may require data recovery, dependent on the type and severity of impact.

4.3.13.3. <u>Unavoidable Adverse Impacts</u>. The mitigation proposed above should reduce impacts to cultural resources to an acceptable level.

4.3.14. <u>Paleontology</u>

4.3.14.1. <u>Anticipated Impacts</u>. No impacts to paleontological resources would occur because no significant resources occur in the project area.

4.3.15. <u>Social Environment</u>

4.3.15.1. <u>Anticipated Impacts</u>. As indicated in Section 2.2.4.3, construction of a dam and reservoir at Rock Creek would require only about 100 workers at the point of peak employment. Only about 40 workers would not be local residents, and it is likely that few of these would bring families to the area, given the relatively short-term and seasonal nature

of the construction effort. Consequently, temporary population growth effects resulting from project construction would be very limited. Some of these non-local workers might bring trailers and mobile homes with them, and available housing in nearby communities such as Kremmling, Yampa, and Oak Creek should be sufficient to meet any additional worker housing demands. Increased demands on public and private services and local infrastructure would be virtually unnoticeable, compared to demands associated with summer tourist activity. Effects on public school enrollments would also be minimal, due to the temporary and seasonal nature of construction efforts and the small proportion of non-local workers. Similarly, the small and temporary population influx caused by project construction would not be expected to have any significant effects on the social characteristics of local communities or the ways of life of existing residents.

As noted in Section 4.3.10, one allotment out of the three affected would be impacted significantly by the location of a reservoir on Rock Creek. One ranch has private landholdings within the reservoir basin. Although neither of these operations would have key base properties inundated by the reservoir, the loss of grazing lease areas could negatively affect the viability of one of the operations, especially during a time of depressed livestock markets when any additional costs associated with acquisition of alternative grazing areas may be prohibitive. However, although the individual affected rancher may experience reduced opportunities and satisfaction, no significant effects on overall social conditions of the area would result from this reduction in grazing access.

Construction and operation of the Rock Creek Reservoir alternative would likely contribute to dissatisfaction among some local and nonlocal residents who favor the preservation of the existing environmental and recreational resource characteristics at Rock Creek. Grand County officials have expressed support for the Rock Creek alternative (see Section 2.4). Rock Creek recreationists contacted during onsite interviews expressed opposition to the location of a reservoir at the site, as have a number of others who provided comments during the EIS scoping and analysis process. In addition, some residents of the town of McCoy and other areas immediately downstream from the reservoir may experience dissatisfaction related to perceived risks of dam failure. Should such dissatisfaction coalesce into active opposition to the project, considerable social conflict among area residents would likely result, since there appears also to be public support for the project among both local residents and public officials.

In addition to these direct and largely short-term impacts of the dam and reservoir project, there could also be some long-term indirect impacts on the social and cultural characteristics of nearby communities. As noted in Section 3.16.1, traditional rural life styles continue to be important in those parts of Routt County which have been less heavily influenced by tourism-related growth. To the extent that development of the Rock Creek Reservoir would contribute to an expansion of tourism-related activities in nearby communities, the ongoing erosion of these traditional social and cultural conditions would be hastened. Such changes would be welcomed by some area residents who favor economic development and community growth.

However, others who place a high value on traditional small-town and rural social structures and life styles would experience such changes as negative impacts.

In summary, the development of a dam and reservoir at Rock Creek would not be expected to induce any major project-related population growth in the area, and would therefore not result in any significant social disruption or overloads of local service infrastructures. Inundation of grazing land would negatively affect one operation, resulting in potentially significant losses. Probable long-term effects involving recreation-related development could contribute to a more rapid disappearance of the traditional rural social and cultural characteristics of surrounding communities. Increased social dissatisfaction among some residents and possible social conflict between supporters and opponents of the project would also be anticipated to result.

4.3.15.2. Mitigation. The mitigation proposed for the grazing loss should prevent adverse impacts on ranching operations.

4.3.15.3. Unavoidable Adverse Impacts. Possible impacts involving dissatisfaction among some local and non-local individuals, potential conflict among project opponents and proponents, and long-term social change would generally not be subject to resolution through mitigation programs.

4.3.16. Economics

4.3.16.1. Anticipated Impacts. A cost/benefit analysis was conducted for the Rock Creek Reservoir and is explained in Appendix B. Due to the lease with Denver, the cost/benefit value was 2.7 for the reservoir indicating a very viable project economically. For the region comprised of Routt and Grand counties, the major economic impacts of the development of Rock Creek Reservoir would be related to construction activities, recreational use, and livestock grazing. The releases from the reservoir would likely never be used in the two-county area, therefore, production-related economic activity would occur either on the East Slope, for which an EIS already exists (U.S. Army Corps of Engineers, 1986) and for which these releases would play a minor role in water supply, or somewhere on the West Slope as discussed in Section 4.3.3.1. The major changes in recreational use include: (1) loss of stream fishing in the Rock Creek drainage, (2) gain in reservoir recreation in Rock Creek, and (3) changes in wildlife opulations or their habitat which results in changes in recreation use or wildlife-human competition.

The construction period for Rock Creek dam, including the relocation of both transmission lines and Highway 134 would require 2 years, and would employ a maximum of 60 local and 40 imported personnel, primarily during the 3-month summer period. An average annual salary of $25,000 for a construction worker (which is consistent with the proportion of total household income per employed person in the two counties for the

construction sector), would mean an additional $2,100 in household income would be paid to each construction worker per month. A total of 826 man-months are forecast by Morrison-Knudson over a 2-year period, 391 in the first calendar year, and 435 in the second calendar year. Thus, an additional $821,100 of increased household income is projected for the first year, and $913,500 for the second year. Of this amount, 60 percent would be paid to locally hired workers and 40 percent would be paid to imported labor. Given that the imported labor would likely be managerial or special skill, the proportion of income paid to local workers would likely be somewhat less.

Further, it is probable that the expenditure patterns of imported laborers would reflect fewer local purchases. Profiles of construction workers suggest that about half of the income earned by imported labor would be spent locally, compared to the nearly 100 percent for local residents. Thus, the effective increase in local household income from construction labor would be approximately $660,000 for the first year of construction and $740,000 for the second. The personal income multiplier for this two-county region is approximately 1.8 (this is a Type III multiplier, which accounts for the expenditure of household income outside the region, even though sectors exist within the region, such as the purchase of retail goods outside the two-county region). Thus, the total personal income generated from wage payments for the 2 years of construction would range between $1,188,000 for the first year and $1,332,000 for the second year. Which of the two counties would receive the major portion of these expenditures would depend upon the location of residences of hired labor.

In addition to hired labor, some equipment and materials would likely be leased or purchased locally, such as heavy equipment for reservoir clearing and excavation, road construction, and transmission line relocation. The budgeted expenditures for these items are approximately $600,000 per year. Using a local construction multiplier of 1.6 (for total expenditures), this would mean approximately $960,000 additional sales in the two-county region, of which approximately $340,000 to $390,000 would be captured in household income in each of the 2 years. Note that these income and employment increases are less than 5 percent of current levels in the two-county region. Thus, while the effect of construction would be significant for some individuals, it would be small relative to the total county activity. Mitigation costs would be approximately $1,600,000. There would be a land purchase of $120,000 in addition to engineering and permitting costs of $4,213, but the location of these expenditures is unknown.

Local ranchers in the Rock Creek area have been identified and contacted regarding any changes and costs they would suffer as a result of the reservoir construction. One rancher indicated that possible inundation of a bedding ground would occur near Horse Creek, but that the loss of AUMs in the stream bottom would not be significant with respect to their operations or profitability. A second rancher would suffer a loss of approximately 11 percent of his AUMs in a yearling operation. While the three ranchers would lose approximately 250 AUMs, this loss would not be a significant change in the economy of the two-county region, even though these ranchers may not be able to replace their lost grazing.

The projected visitation to Rock Creek Reservoir is given in Table 4.3.16.1. For 1990, approximately 246,000 visitor-days could be expected at Rock Creek with the planned campground facilities. As noted in the Recreation section, this number appears to be high based on present visitation to Steamboat Lake. A more realistic short-term visitation estimate for Rock Creek might be 200,000 visitor-days. Because it is unlikely that any non-resident boaters would be attracted to Rock Creek as a destination reservoir, the expenditures by resident fisherman were used to project economic impacts on the two-county region.

Table 4.3.16.1
Projected Visits to Rock Creek
and Muddy Creek Reservoirs 1/

Site	Year 1990	2000	2010	2035
Rock Creek	246,713	275,232	302,027	248,571
Muddy Creek	142,110	164,687	186,415	233,604

1/ Assuming 50 campground units would be available.

McKean and Nobe (1983) report expenditures per capita of \$300 for fishing, an average visit rate of 10 trips per recreator per year for fishing, an average of about 1.2 visitor-days per trip (due to many day trips for fishing), with an average of \$30.00 variable expenditure per trip. Application of these estimates results in an average expenditure of \$25.00 per visitor-day. This value is reasonably comparable to boating studies in other areas. Thus, a total of about \$5,000,000 in expenditures for boaters on Rock Creek might be expected in 1990. Note that at least a part of these expenditures would not occur locally, although there are no data from which to estimate the proportion of strictly local sales. Therefore, the \$5 million is an upper estimate of direct expenditures. Using the economic multipliers for local (resident) fishing in the two-county region of 1.49 (McKean and Nobe, 1984), the total maximum economic expenditure related to recreation on the Rock Creek Reservoir would be approximately \$7,450,000, which would result in an increase in household income of \$2.3 to \$2.6 million, and an increase in the number of jobs of approximately 108 full-time equivalents.

These projections appear to be somewhat high for three reasons. First, it is likely that only a portion of total expenditures on fishing would be made in the two counties; second, given the current per capita income for the two counties (approximately \$14,000), the income per job created of \$25,000 to \$30,000 per year (assuming about 40 percent of total sales is captured by household incomes) appears high; finally, the fact that some of these visits would be simple transfers from one site in the two-county region (such as Steamboat Lake) to Rock Creek would suggest that a significantly smaller increase in recreational expenditure should be

expected. The amount of visitor-days that are simply transfers is unknown, although Steamboat Lake visitation alone is estimated from the demand study model to be reduced by approximately 40,000 visitor-days. It is likely that most of this visitation would be a redistribution from existing sites in this region. However, the total reallocation for the two-county region cannot be readily estimate from the data, simply because the actual visitation to each site within the county is unknown. In addition, reduction in visitation during extreme dry periods would reduce the income stream for a year or more. Income from visitation could be reduced to near present levels.

Approximately 2,000 visitor days would be lost to the stream fishery on Rock Creek, and using the above data, this would result in approximately $100,000 of retail sales loss in the area, and an accompanying four jobs. Quite clearly, the stream fishing loss would have insignificant economic impacts. An additional cost of stocking would also be required, estimated to be about $10,000 annually.

No changes have been identified for big game populations resulting from the construction of Rock Creek Reservoir. Hunters in the area generally use the available campsites at Shoe and Stocking Creek during the hunting season, but other campsites are available in the area. There is no anticipated change in hunting or its related economic activity for the Rock Creek Reservoir.

Operations models of the Rock Creek Reservoir indicate that no significant impact on the flows of the Colorado River through the reaches of intense floating recreation would occur with Rock Creek Reservoir with either sales scenario. A major factor is that existing East Slope water rights can currently reduce flows below the minimum necessary to support floating activities without the reservoir.

4.3.16.2. Mitigation. Because there are no significant adverse economic effects associated with the reservoir, no mitigation would be required.

4.3.16.3. Unavoidable Adverse Impacts. There are no significant unavoidable adverse economic impacts in the region.

4.3.17. Transportation.

4.3.17.1. Anticipated Impacts. Rock Creek Reservoir would inundate a ½-mile section of State Highway 134 at the upper end of the reservoir (Fig. 2.1). This section would be realigned by moving slightly uphill, and a widened section would be added as an observation turnout. The widened section would allow State vehicles easy access and facilitate snowplowing. The area would be designed to accommodate approximately 15 vehicles. There would be short-term impacts on vehicular traffic on Highway 134 during construction of the road relocation. Traffic could be reduced to one-way or a detour provided. At present Highway 134 is moderately used.

Most of the aggregate required for the construction of Rock Creek dam would be obtained from streambed deposits in the proposed reservoir basin. Approximately 260,000 cu yd would be produced from this source. Aggregates for use in facing, bedding, and structural concrete mixes would be obtained from commercial sources in the vicinity of Kremmling. Hauling these materials would increase truck traffic on State Highway 134 and U.S. Highway 40 during one construction season (June to November). Both cement and pozzolan (fly ash) would be trucked to the site by semi-tractors pulling 20-ton bottom dump hopper trailers. Approximately 8-10 truck deliveries would be required each day for about 80 days. Again, there would be a short-term increase in traffic-related problems.

4.3.17.2. Mitigation. Increased traffic problems related to materials hauling would be mitigated by accepted traffic control measures, including: warning signs, truck speed limits, and flag persons where necessary. During road relocation one-way or detour traffic controls would be instituted.

4.3.17.3. Unavoidable Adverse Impacts. There would be unavoidable short-term increases in traffic on State Highway 134 and U.S. Highway 40 during one construction season, and short-term traffic delays on Highway 134 during road relocation.

4.4. Muddy Creek Dam and Reservoir

4.4.1. Geology

4.4.1.1. Anticipated Impacts. There are no significant locatable or leasable mineral deposits in the Muddy Creek Reservoir area. Some salable deposits of construction aggregates have been identified above and below the proposed dam axis and could be utilized in the construction of Muddy Creek dam. The quantities used would be relatively small and most deposits are located in the proposed reservoir basins where impacts would be insignificant. If a borrow area for construction aggregates below the dam axis were used, there could be impacts to the visual resource.

The seismic study summarized in Section 3.2.3 concluded that faults in the Muddy Creek basin are either non-seismogenic or there is no conclusive evidence of seismogenic movements. Other seismically induced hazards including surface faulting, liquefaction, reservoir seiche, and induced seismicity are believed to be low or virtually non-existent in the Muddy Creek project area. Thus, no impacts related to seismicity are likely.

4.4.1.2. Mitigation. Reclamation of any borrow area developed below the dam axis would be required.

4.4.1.3. Unavoidable Adverse Impacts. There are no significant unavoidable adverse impacts in relation to geology, minerals, or seismicity.

4.4.2. Soils

4.4.2.1. Anticipated Impacts. The general impacts that would occur to soil resources as a result of reservoir construction and land inundation as presented in Section 4.3.2 also apply to this alternative.

Inundation. Construction and operation of this alternative would inundate a total of 1,200 acres of land at the normal maximum reservoir operating level. Table 4.4.2.1 summarizes the area of each soil association in the study area that would be inundated by the reservoir.

Approximately 744 acres of farmlands of state and local importance, including primarily irrigated haylands and pasture, would be inundated. The loss of these productive soils would be considered significant.

At normal maximum operating level, the reservoir would have approximately 24.7 miles of shoreline. Table 4.4.2.1 summarizes the distance that the shoreline would cross each soil association.

Table 4.4.2.1. Summary of acres of soil associations inundated and crossed by the shoreline of the proposed Muddy Creek Reservoir.

		Inundation			Shoreline	
Soil Association	Study Area (acres)	Area (acres)	Percent of Study area	Percent of Inundation	Length (miles)	Percent of Shoreline
Cumulic Cryaquolls-Tine	7,360	1,116	5	93	3.7	15
Aaberg-Waybe-Binco	1,840	42	<1	4	4.5	18
Harsha-Leavitt	12,260	36	<1	3	12.3	50
Quander-Youga-Anik	60	6	<1	<1	0.4	2
Cimarron-Mayoworth-Moerd	80	0	0	0	0	0
Rock Outcrop	0*	0*	0*	0*	3.8	15
Totals	21,600	1,200	6	100	24.7	100

* = Area of rock outcrop previously included in the other soil associations.

The upstream portion of the shoreline restricted to the alluvial flood plain of Muddy Creek would fluctuate over a wide zone. For instance, assuming a slope of 0.4 percent on the Muddy Creek floodplain and a normal annual water level fluctuation of 10 feet, the fluctuation zone would be approximately 2,600 feet long. In contrast, assuming an average sideslope of approximately 25 percent around the shoreline of the reservoir, the fluctuation zone would be approximately 40 feet wide. During a drought year such as 1977, the water level would drop approximately 100 feet resulting in a fluctuation zone of approximately 5 miles and 400 feet for the above slope situations, respectively.

The character of the shoreline for the most part would be determined by the type of soil, its stability and texture; slope; and depth. Consequently, the suitability of the shoreline to recreation activities such as fishing, swimming, and boating would vary according to these conditions. The criteria presented in Section 4.3.2.1 define broad suitability classes for recreation activities including: highly suited, moderately suited, and poorly suited soils.

The shoreline occurring on soils of the Cumulic Cryaquoll-Tine association (3.7 miles) would primarily be located at the upper reaches of the reservoir where Muddy Creek would discharge into the reservoir. A sediment delta would form in this part of the reservoir that, combined with the loamy soils, would be mudflat when the reservoir level dropped to lower levels. These mudflats would have limited use and would be difficult to access and travel across until sufficiently dried. The shoreline on these soils would be poorly suited to recreational activities.

The shoreline occurring on soils of the Aaberg-Waybe-Binco association (4.5 miles) would consist primarily of silts and clays with a small amount of gravel. Due to the high clay content of these soils, the shoreline would be relatively soft, unstable, and therefore, poorly suited for recreational activities.

The shoreline occurring on soils of the Harsha-Leavitt association (12.3 miles) would consist primarily of silts and sands, with minor amounts of gravels and cobbles. The shoreline would be relatively stable and moderately suited for recreational activities.

The shoreline occurring on soils of the Quander-Youga-Anvik association (0.4 miles) would be similar to that described above for the Harsha-Leavitt association.

The shoreline occurring on rock outcrops (3.8 miles) would be relatively stable due to the massive nature of the rock and thus would be little affected by fluctuating water levels and wave action. The shoreline that would occur on this unit would be poorly suited for recreation activities due to steep slopes.

Compilation of these estimated shoreline characters indicates that approximately 12.7 miles or 51 percent of the shoreline would be moderately suited for recreation activities and approximately 12 miles or 49 percent of the shoreline would be poorly suited for recreation activities.

There is a potential that concentration of cattle at certain points along the shoreline of the reservoir could cause increased erosion and instability of the soils as well as a reduction of suitability for recreation. However, the size of these areas where concentration might occur would be relatively small relative to the total area of shoreline, and thus, would not be considered significant unless located within or near a high use recreation area.

Facilities Construction. Table 4.4.2.2 summarizes the areas of soil disturbance that would occur due to facilities construction and operation. Several borrow areas are planned upstream and downstream of the dam site. No specifics as to the actual location and size of the sites have been presented. It is assumed that the total areas would be approximately 40 acres. Development of these borrow areas would result in alteration of the topography at the site. The soil resources would be lost at these sites unless salvaged.

No specific plans have been formulated for recreation sites at the reservoir. It is assumed that facilities of similar type and size as proposed for the Rock Creek site would be developed at this reservoir. The likely sites of this development would be between Highway 40 and the reservoir. The predominant soils in this area are of the Harsha-Leavitt association. For the purposes of this study, it was assumed that construction and operation of the recreation facilities would disturb or destroy approximately 10 acres. Slope is the only major limitation to recreation site development for this soil type. Thus, if the development occurred on relatively gentle slopes, the soils should be well suited for such development.

Except for the loss of farmlands of state and local importance, the impacts on soils due to construction and operation of this reservoir site would not be considered significant.

4.4.2.2. Mitigation. A successfully implemented site-specific plan for runoff, erosion, and sediment control, as well as a revegetation plan, would greatly reduce increased erosion, soil loss, and off-site sedimentation due to project construction. Site-specific plans would be developed for the Muddy Creek site. The general points and procedures of such plans are discussed in Water Quality (Section 4.4.3.5). A detailed soil and water monitoring and mitigation plan applicable to either site is included at Appendix C. Farmlands of local and state importance lost due to inundation could not be mitigated by replacement or developing new areas. Soils that are suitable and feasible for development are finite in the vicinity of the reservoir and the vast majority of soils suitable for irrigating and farming in the area have already been developed. However, the purchase of affected farmlands would mitigate the economic impacts associated with the loss of these farmlands. Should cattle concentrations occur along the shoreline within or near recreation sites, the areas could be fenced to preclude cattle concentration near recreation sites. No practical mitigation could alter the shoreline to make it more conducive to recreation.

Table 4.4.2.2. Summary of acres of soil associations that would be destroyed or disturbed due to facilities construction and inundation at the Muddy Creek Reservoir Site.

Soil Association	Study Area	Dam Site Construction (including spillways)	Borrow Areas	Recreation Sites	Primary Access Road	Secondary Access Road	Highway 40 Upgrade	Transmission Line	Total Area	%
				(ACRES)						
Cumulic Cryaquolls-Tine	7,360	5.0	10	0	0	0.5	1.8	0	17.3	0.2
Aaberg-Waybe-Binco	1,840	0.0	0	0	0	0.0	0.0	0	0.0	0.0
Harsha-Leavitt	12,260	4.0	30	10	3.6	10.3	1.1	1.0	60.0	0.5
Quander-Youga-Anik	60	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
Cimarron-Mayoworth-Moerd	80	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
Rock Outcrop	0*	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
Totals	21,600	9.0	40	10	3.6	10.8	2.9	1.0	77.3	-
Percent of total	100	>0.1	0.2	>0.1	>0.1	>0.1	>0.1	>0.1	0.3	-

* = Area of rock outcrop previously included in the other soil associations.

4.4.2.3. Unavoidable Adverse Impacts. The loss of approximately 744 acres of farmlands of state and local importance could not be mitigated directly and would therefore be considered an unavoidable adverse impact.

4.4.3. Surface-Water Resources

4.4.3.1. Projected Water Uses for Muddy Creek Reservoir. The projected water uses for Muddy Creek Reservoir are identical to those described for Rock Creek Reservoir in Section 4.3.3.1, i.e., both Metro Denver Lease and West Slope demand scenarios; but the impacts assessment is based on only the short-term (25-year) firm Metro Denver Lease scenario.

4.4.3.2. Muddy Creek Conditions Below Dam

Hydrology. Similar to the hydrology analysis performed on the Rock Creek alternative (see Section 4.3.3.2), operational models for Metro Denver Lease and West Slope sales scenarios were developed for the Muddy Creek project. Annual operations for the Metro Denver Lease are summarized in this section as a basis for impacts assessment. Monthly summary data for both demand scenarios are presented in Appendix A. The complete spreadsheets for the operational models and a discussion of the various inflows and outflows are given in the Hydrology Technical Report (Resource Consultants, Inc., 1987a).

Briefly, the inflows to the Muddy Creek project were developed from the Kremmling gaging station, adjusting by drainage area scaling for the difference in location between the gage and the Site C location. Controlled releases included the Colorado River demands, a 13 cfs instream flow, and project water sales. While there is no Colorado Water Conservation Board instream flow filing on Muddy Creek, an analysis based on the Instream Flow Incremental Methodology was completed. A 13 cfs instream flow would provide reasonable protection for the aquatic resource. Unlike the Rock Creek project which is located on Forest Service land, Muddy Creek dam is on Bureau of Land Management land for which no channel maintenance flow is required; however, a channel stability analysis was completed for Muddy Creek (see Hydraulics and Channel Stability, below). Reservoir spills occurred whenever the 46,800 acre-feet project storage capacity was exceeded. In a typical water year such as 1972 (Fig. 2.5.5), the reservoir would spill twice (May--9,450 acre-feet and June--14,794 acre-feet). Over the period of record the average annual spill would be 27,906 acre-feet. Here a spill is taken to be an uncontrolled release through the outlet works or over the spillway or a combination of both.

Table 4.4.3.1 summarizes on an annual basis the discharge conditions for the Metro Denver Lease and the differences in flow as a result of the proposed project. Fig. 4.4.3.1 compares reservoir inflow and outflow on a monthly basis. The change in outflow relative to inflow is illustrated in Fig. 4.4.3.2 and provides insight on project impacts on flow regime. Similar to Rock Creek, the average monthly discharge below the project

Table 4.4.3.1
Discharge Summary
Muddy Creek Reservoir Operations

		Metro Denver Lease		
Water year	Inflow to reservoir (cfs) 1	Flow below reservoir (cfs) 2	Difference in flow (cfs) 3	Percent change (%) 4
1962	151	154	2	2
1963	42	54	12	29
1964	60	55	-6	-9
1965	100	91	-8	-8
1966	42	49	7	16
1967	69	70	1	1
1968	91	88	-3	-3
1969	77	81	5	6
1970	133	130	-2	-2
1971	153	149	-4	-3
1972	94	100	6	6
1973	106	102	-5	-5
1974	109	110	2	1
1975	109	112	3	2
1976	89	90	1	1
1977	35	84	48	137
1978	119	69	-50	-42
1979	136	132	-4	-3
1980	105	109	4	4
1981	55	73	18	32
1982	92	68	-24	-26
Average	94	94	0	7
Minimum	35	49	-50	-42
Maximum	153	154	48	137

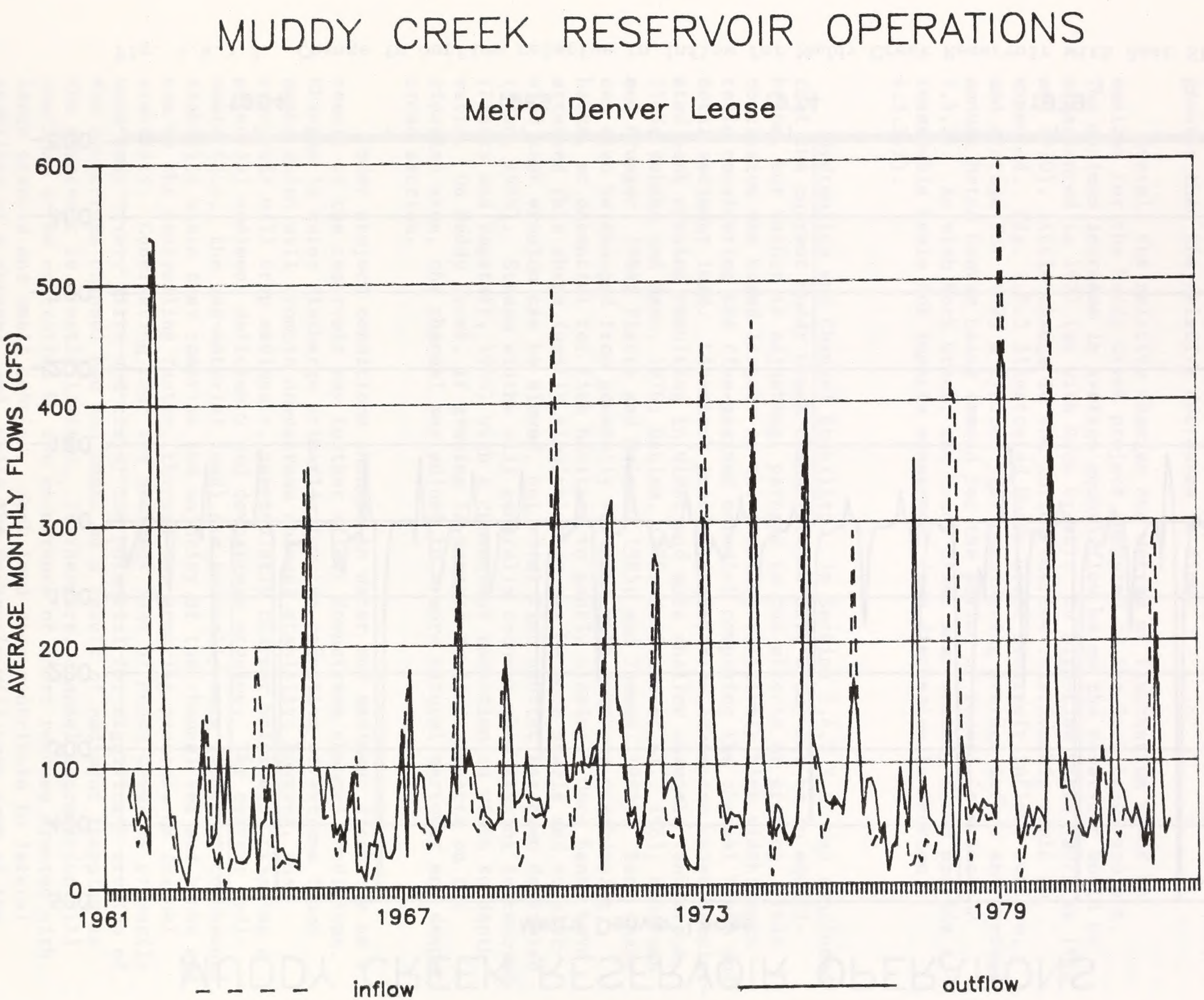


Fig. 4.4.3.1. Muddy Creek Reservoir inflows and outflows with Metro Denver Lease.

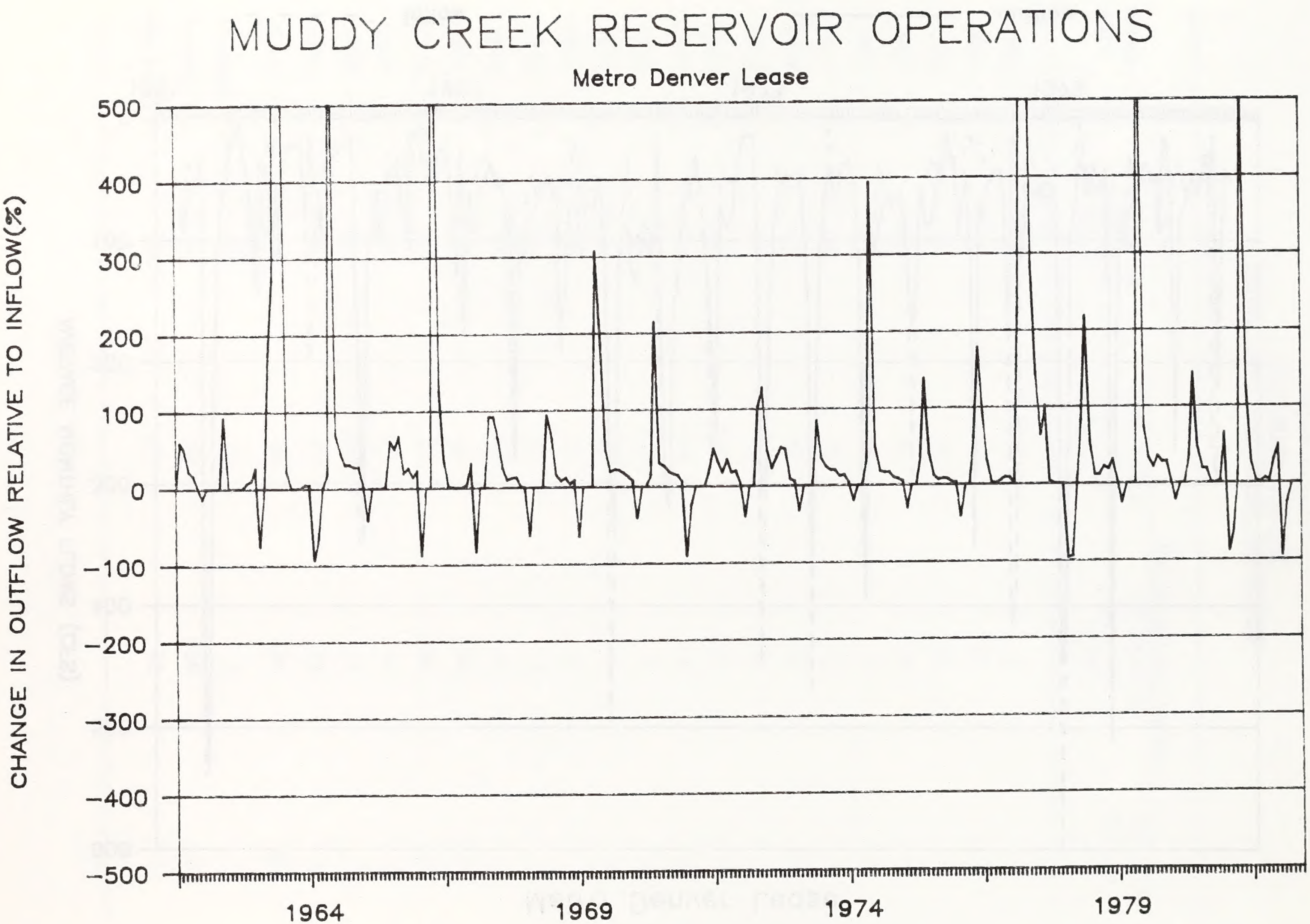


Fig. 4.4.3.2. Change in outflow relative to inflow for Muddy Creek Reservoir with East Slope sales.

would be larger than pre-project conditions (inflow) during much of the year. In addition, the relative increases in flow would be consistently greater than the relative decreases in flow.

Overall the relative changes and degree of fluctuation would be smaller for the Muddy Creek project compared to the Rock Creek project. The maximum increase in average annual flow below the reservoir would be experienced in 1977 (as with Rock Creek). In high-flow years (such as 1962 and 1970), little change in the inflow/outflow relationship would be expected. Fig. 2.5.5 illustrated Muddy Creek Reservoir inflow, outflow, and storage for 1972, a typical year considering average inflow and average annual Metro Denver Lease demand for the period of record (see Section 2.5.7). As with Rock Creek, the Muddy Creek mean monthly flows provide a reasonable basis for impacts assessment (see discussion in Section 4.3.3.2).

Hydraulics and Channel Stability. In Section 3.4.2.2 it was concluded that the current Muddy Creek channel below Site C may not be in equilibrium, but rather is adjusting, perhaps to the effects of grazing. This conclusion was based largely on the existing relatively high width/depth ratio considering the fine-grained material composing the channel banks and total sediment load. Livestock grazing in riparian areas can cause accelerated bank erosion resulting in wider and more shallow channels (Gunderson, 1968; Behnke and Zaun, 1976; Dahlem, 1979; Kauffman et al., 1983; Kauffman and Krueger, 1984; Platts and Nelson, 1985; and Thomas, 1986). Bank shape can also be changed from generally vertical with numerous overhanging banks, so essential for fish habitat, to gently sloping. Once banks have attained this shape (gently sloping) they may be more stable and accelerated bank erosion can be slowed, but vital fish habitat has been destroyed (Bohn, 1986). Stream widths will generally recover when grazing is removed (Platts and Wagstaff, 1984) with a consequent reduction in width to depth ratio. On Muddy Creek, if grazing is managed to limit impacts on the riparian area, the channel may adjust to a more natural narrower and deeper cross section.

Under project conditions changes in water and sediment discharge as a result of the reservoir may further affect downstream channel conditions. Changes in water discharge primarily involve reduction of extreme flood peaks which will promote downstream channel stability; however, the reservoir will trap sediments, particularly coarser materials, creating a potential sediment deficiency and downstream erosion. The coarser sediments (i.e., the bed-material load) are generally more important to channel stability since they comprise the majority of the channel bed and banks and can be the controlling factor, through the armoring process, on channel stability. Considering that the sediment load of Muddy Creek is primarily wash load (i.e., silts and clays) the potential for significant erosion of the downstream channel bed and banks as a result of sediment trapping in the reservoir is greatly limited. Furthermore, channel degradation will continue to be controlled by the occurrence of short reaches armored with large gravels and small cobbles. Wash load does contribute to lateral stability of a channel, and, while the reservoir will trap some of the upstream wash load, an adequate supply of fine-grained sediments would still be available from tributary deltas and the watershed contributing below the reservoir.

In addition to erosion related problems, the potential for aggradation below the proposed dam (primarily from tributary supplied sediments) must be addressed under moderated project flow conditions. To determine if an aggradation problem could exist, the sediment supply provided to Muddy Creek below the project and the transport capacity necessary to move that supply were evaluated. The first step in this analysis was to establish a sediment transport relationship to be used in calculating the transport capacity. To estimate the transport capacity, calculations were made based on a combination of the Einstein suspended load calculation (1950) and the Meyer-Peter, Muller (MPM) bedload equation (1948). For application to Muddy Creek, transport capacity calculations were calibrated against the measured data by assuming that the supply of the finest size fraction was in equilibrium with transport capacity for the two measurements preceding the period of highest flow during 1985. This assumption is supported by the USGS who concluded, based on the available measured data, that,

> During the first part of the snowmelt runoff or rising stage period, there were initially large suspended sediment concentrations caused by the flushing of the easily mobilized sediment and sloughing of streambanks. Because of this initial flushing, suspended sediment concentrations peaked before the stream discharge peaked. (Ruddy, 1986, p. 23)

For Site C the two major tributaries entering below the reservoir are Cow Gulch and Horse Gulch. From field observations tributary deltas are present at both of these drainages indicating that they are important sources of sediment. To estimate the sediment supply from these tributaries a unit sediment yield was calculated based on available measured data. The unit sediment yields were applied to the entire remaining drainage area fo 26 square miles (not just to Cow and Horse Gulch) which most likely overestimates the sediment supply from the watershed in the relatively flat region below Site A near the Muddy Creek confluence with the Colorado River. The minimum discharge required to transport all the estimated sediment supply is 225 cfs. Based on Fig. 4.4.3.1, flows of this magnitude are experienced on a regular basis and, therefore, deposition of tributary supplied sediment should not occur under project conditions.

An evaluation of potential changes in planform (i.e., meandering, straight or braided) as a result of the project can be made based on the Lane diagram. Research by Lane (1957) established a relationship between slope, mean annual discharge and planform configuration (Fig. 4.4.3.3). As indicated by Table 4.4.3.1, the mean annual discharge would not change from pre- to post-project conditions. The current channel bed slope below the project is about 0.0004. This value is plotted on Fig. 4.4.3.3 in the meandering portion of the graph, a result that is confirmed by field observations. Given the current plotting position, even substantial changes in slope (i.e., from erosion or depostion) under project conditions would not affect the meandering planform of Muddy Creek. Based on the above results, a significant change in slope is not likely to occur under post-project conditions.

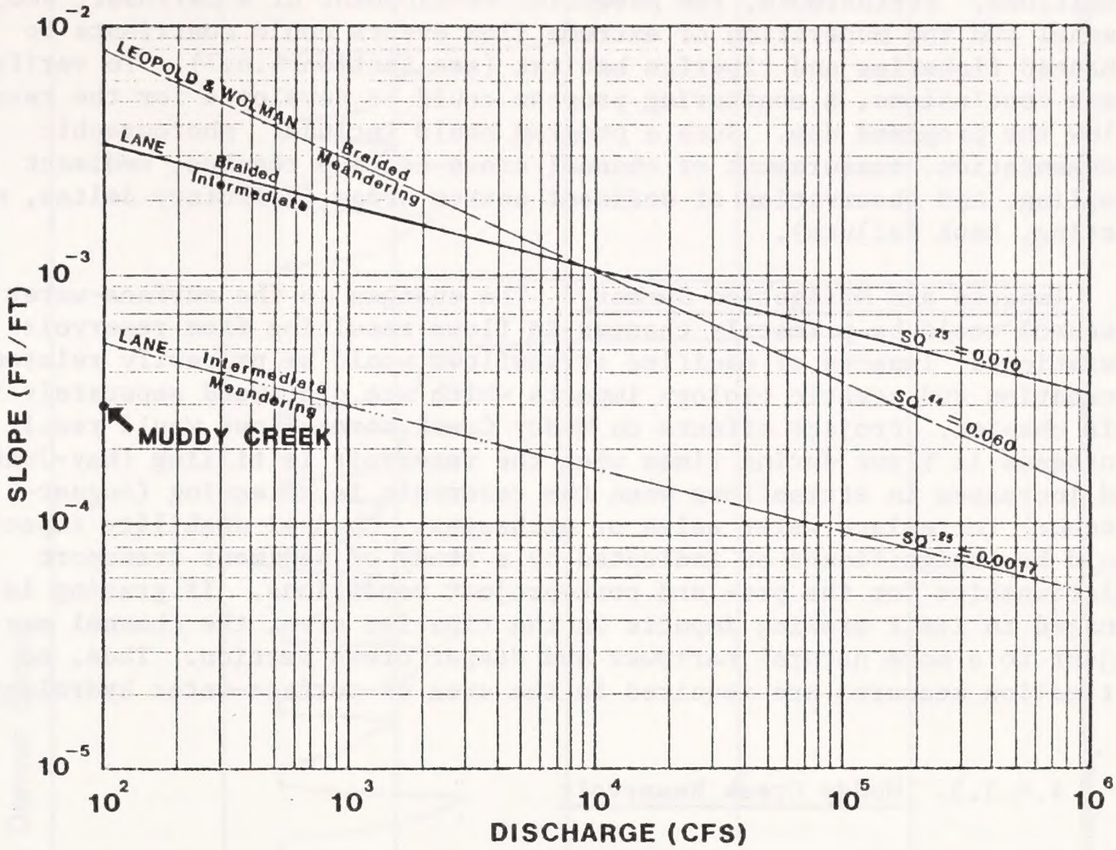


Fig. 4.4.3.3. Slope-discharge relations

It can be concluded that channel stability of Muddy Creek under post-project conditions would not be significantly different than current conditions. Furthermore, the potential development of a narrower, deeper channel and the moderation of extreme flow events could contribute to enhanced fisheries and riparian habitat (see Section 4.4.7). To verify these conclusions, a monitoring program could be developed for the reach below the proposed dam. Such a program could include: photographic documentation, measurement of channel cross-section reaches, sediment sampling, and observation of sediment source areas (tributary deltas, mass wasting, bank failure).

Impacts and Mitigation Summary. The changes to the surface-water resource would be primarily changes in flows resulting from reservoir operations. Impacts of modified streamflows would be primarily related to recreation and aquatic biology impacts which are discussed separately in this chapter. Project effects on Muddy Creek streamflows would result in decreases in flows during times when the reservoir is filling (May-June) and increases in streamflows when the reservoir is releasing (August-October) to replace water sales or exchanges. Channel stability impacts would be insignificant as indicated by a study of sediment transport relationships for the pre- and post-project conditions. If grazing is managed to limit grazing impacts on the riparian area, the channel may adjust to a more natural narrower and deeper cross section. Thus, no mitigation measures are required in the area of surface-water hydrology.

4.4.3.3. Muddy Creek Reservoir

Operations. The operational model described in Section 4.4.3.2 also provided information on conditions in the reservoir, primarily end-of-month storage and pool elevation. Fig. 4.4.3.4 summarizes on a monthly basis Muddy Creek Reservoir storage and Fig. 4.4.3.5 presents reservoir pool elevations for the Metro Denver Lease. During a drought period such as 1977-1978 reservoir operations would eliminate the conversion pool and the reservoir would be practically dry under conditions that occurred once in the 21-year period of record analyzed. During this dry period Muddy Creek Reservoir would not be able to meet the full requirements of the Metro Denver Lease. There would be a shortfall of about 3,000 acre-feet on water delivery under the lease.

Dam Failure Analysis. As with Rock Creek (Section 4.3.3.3), DAMBRK, a dambreak flood forecasting model developed by the National Weather Service, was used to study the flooding effects on the downstream channel from the Muddy Creek damsite through Kremmling and into the Colorado River basin. The site investigated would be located on the western flank of Wolford Mountain, about 4 miles north of the town of Kremmling. The project would consist of an earth embankment dam forming a reservoir with a normal operating storage capacity of 46,800 acre-feet and a maximum capacity of 67,500 acre-feet. The proposed dam would have a height above the streambed of 108 feet and a normal water-surface elevation of 7,475 m.s.l.

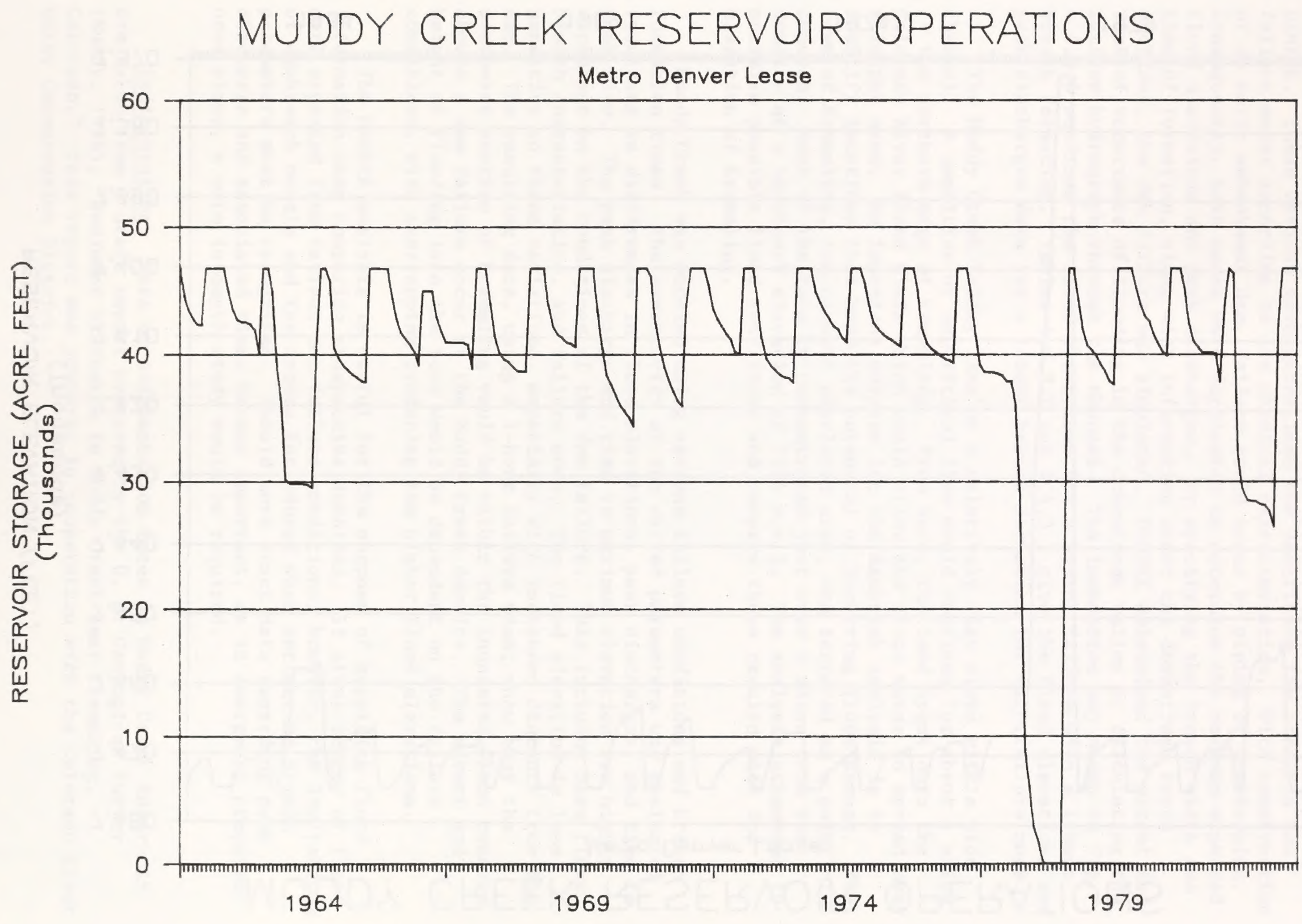


Fig. 4.4.3.4. Muddy Creek Reservoir storage with Metro Denver Lease.

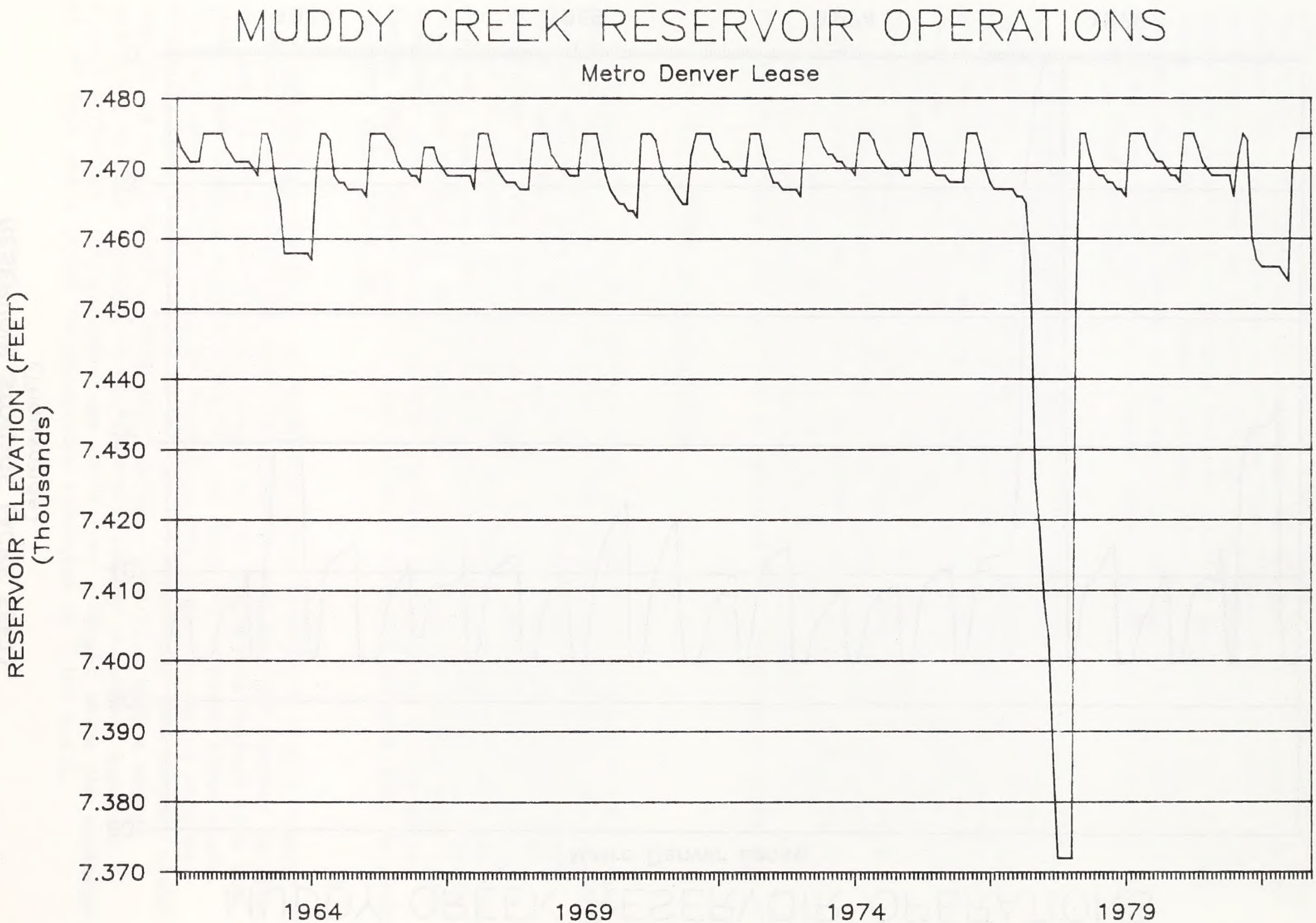


Fig. 4.4.3.5. Muddy Creek Reservoir elevation with Metro Denver Lease.

The Muddy Creek dam was modeled according to the options available on DAMBRK. These options gave guidelines for describing the possible dam failure modes according to its physical characteristics. With construction of an earth embankment dam, failure could occur by piping or overtopping. Consequently, both modes were duplicated to determine the maximum expected flood elevations and peak discharges. By specifying the breach width and time of formation, along with information about the downstream cross sections, the dam failure was simulated. DAMBRK determined the extent and time of occurrence of flooding in the downstream valley by calculating the outflow hydrograph through the channel. The inundation map shown in Fig. 4.4.3.6 outlines the flood elevations for a piping failure with a 1-hour breach formation. Tables 4.4.3.2 and 4.4.3.3 give the flood elevations and peak discharges data for a 1-hour breach formation for each failure mode.

The Muddy Creek Valley lies on a relatively flat slope with a wide channel. A condition of subcritical flow would continue for about 4 miles to the northern edge of Kremmling. From here, the land opens onto the Colorado River flood plain which would allow the flood water to spread over a larger area. An important purpose for the dambreak analysis is to identify locations that have the potential of incurring flood damage. The town of Kremmling, the closest populated area, was targeted as a point of concern. Most of the town is concentrated just over 4 miles from the damsite at a benchmark elevation of 7364 m.s.l. The analysis attempted to maximize possible flood conditions and compare these results with the elevation of Kremmling.

Muddy Creek was modeled using various failure conditions and breach formation times. The sensitivity of the varied parameters was evaluated resulting in differences in flood elevations, peak discharges, and time to peak flow. The peak discharge and time to maximum elevation are highly dependent on the conditions of the dam failure. This includes base flows, breach characteristics, and failure mode. The flood elevation is less sensitive to these variations, especially with increased distance from the dam. The resulting data, using a 1-hour failure time, show that the northeast section of Kremmling would be within the inundated flood contour should a dam failure occur at the Muddy Creek damsite. The extent and height of flooding into the town would be dependent on the failure conditions, with overtopping producing the higher flood elevations.

The DAMBRK analysis is useful for the purpose of supplying flood information when comparing prospective damsites. It gives ranges of flood data expected from various dam failure conditions; however, the limitations of dambreach models and the errors introduced when estimating breach parameters must be recognized. Should more exact data regarding peak discharge and associated times become important, as in emergency preparedness plans, a more in-depth study would be required.

Sedimentation. Data on sedimentation rates in Muddy Creek Reservoir are taken from a draft report prepared by the U. S. Geological Survey (Ruddy, 1986), "Sediment Discharge in Muddy Creek near Kremmling, Colorado." This report was prepared in cooperation with the Colorado River Water Conservation District.

Table 4.4.3.2
Dambreach Analysis, Muddy Creek Damsite
Embankment Failure Condition

Cross section	River mile from dam	1-Hour Breach Information Peak flow (cfs)	Max. elev. (ft)	Initial elev. (ft)	Maximum top width (ft)
Dam	0.00	498067	7444.27	7360.0	484.0
K-25	2.31	453104	7402.12	7354.0	978.0
K-23	2.87	433351	7397.54	7350.0	1320.0
K-19	4.17	373570	7389.01	7347.0	1125.0
K-15	5.68	340925	7376.59	7342.0	1001.0
K-14	6.06	335618	7375.70	7337.0	1620.0
K-12	6.62	331772	7368.93	7335.0	937.0
K-6	7.91	304422	7357.09	7332.0	4354.0
N-1	11.73	160707	7344.54	7320.0	7342.0
N-2	13.12	87386	7343.68	7310.0	592.0

Table 4.4.3.3
Dambreach Analysis, Muddy Creek Damsite
Overtopping Failure Condition

Cross section	River mile from dam	1-Hour Breach Information Peak flow (cfs)	Max. elev. (ft)	Initial elev. (ft)	Maximum top width (ft)
Dam	0.00	776939	7458.63	7360.0	553.0
K-25	2.31	732151	7414.67	7354.0	1070.0
K-23	2.87	704923	7410.64	7350.0	1584.0
K-19	4.17	632405	7401.75	7347.0	1187.0
K-15	5.68	590697	7386.69	7342.0	1109.0
K-14	6.06	584030	7386.03	7337.0	1718.0
K-12	6.62	581615	7377.26	7335.0	1037.0
K-6	7.91	532154	7363.16	7332.0	5600.0
N-1	11.73	304543	7353.42	7320.0	7508.0
N-2	13.12	97206	7353.44	7310.0	671.0

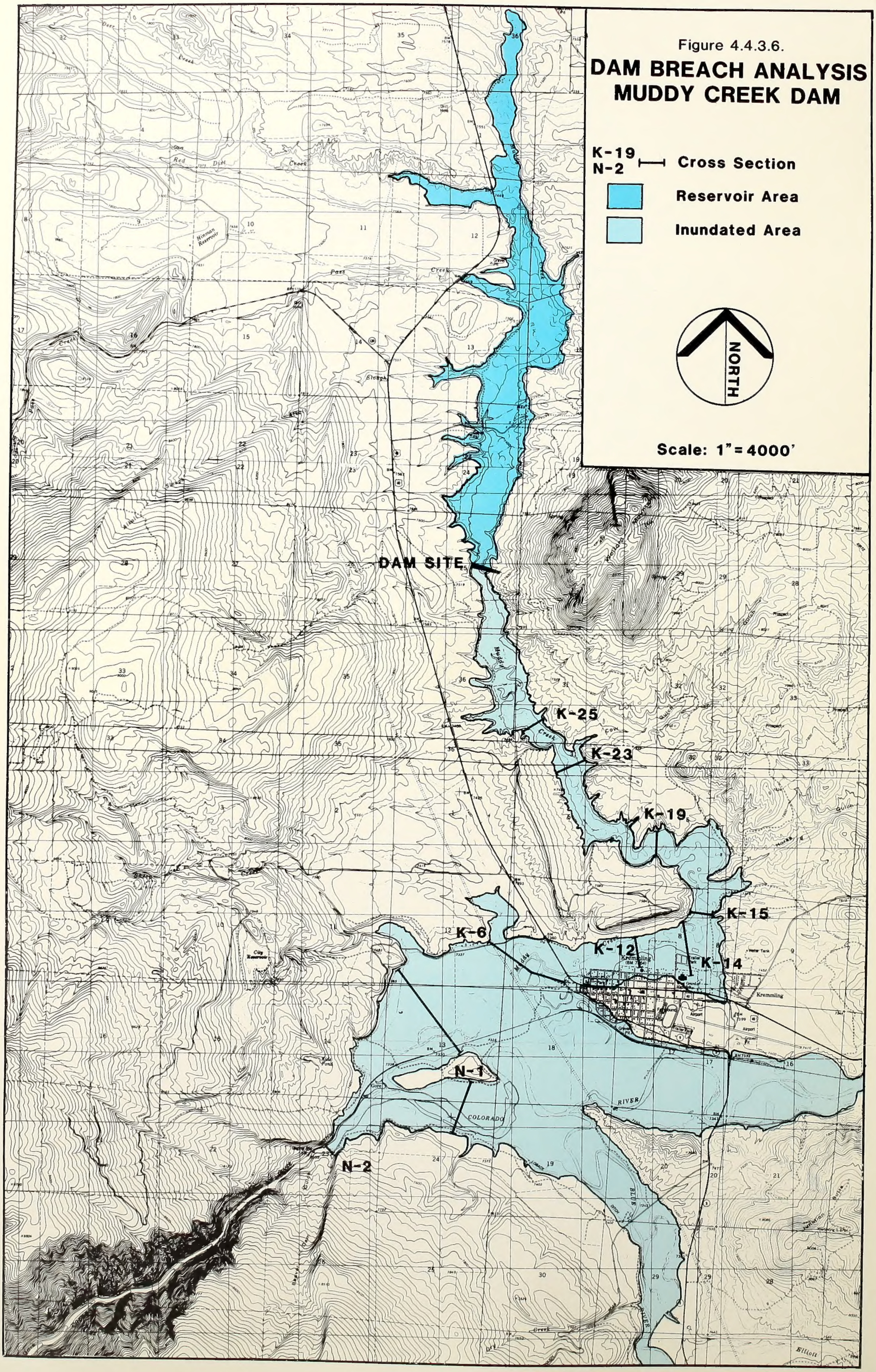


Figure 4.4.3.6.
DAM BREACH ANALYSIS
MUDDY CREEK DAM
K-19
N-2
Cross Section
Reservoir Area
Inundated Area
NORTH
Scale: 1" = 4000'
DAM SITE
K-25
K-23
K-19
K-15
K-6
K-12
K-14
N-1
N-2
Kremmling
COLORADO
RIVER

Suspended and bedload-sediment data were collected on Muddy Creek near Kremmling to determine total sediment discharge near the proposed reservoir. Statistical relations between suspended-sediment discharge and water discharge and bedload discharge and stream discharge were determined and total sediment discharge was estimated using the statistical relations and stream discharge. Total sediment discharge was greater prior to the annual peak stream discharge and decreased thereafter. At least 97 percent of the total sediment transport was suspended sediment. Mean annual total sediment discharge in Muddy Creek near Kremmling was estimated at 83,000 tons per year for the 1983 through 1985 water years.

The same conservative approach for estimating reservoir trap efficiency applied for Rock Creek (see Section 4.3.3.3) was used for Muddy Creek. That is, the Churchill method was applied and supported by the assumption that for reservoirs with a storage volume greater than 10,000 acre-feet, the trap efficiency will be 100 percent. While this is the most conservative approach to estimating loss in reservoir storage due to sedimentation, it does not consider the many site-specific factors, including sediment characteristics, that determine sediment deposition in a reservoir. These factors are considered in the discussion of water quality characteristics below the proposed Muddy Creek Reservoir (see Section 4.4.3.5). Suspended sediment samples collected at streamflow gaging station 09041500 Muddy Creek at Kremmling had a mean size distribution of 53 percent clay, 41 percent silt, and 6 percent sand. The size distribution of the suspended sediment was used in the calculation because it accounted for over 97 percent of the sediment flowing into the proposed reservoir. The initial specific weight was estimated at 48.3 lb/ft^3. The average specific weight of the sediment deposits will increase over time as compaction occurs and the void space diminishes. Average specific weights were calculated for several time periods (Strand, 1974) during the expected life of the reservoir. The average specific weight of the deposits are expected to increase to 59.4 lb/ft^3 after 25 years and to 65.4 lb/ft^3 after 100 years.

The weight of the sediment deposits in the reservoir can be estimated for a period of interest by multiplying the mean annual total sediment discharge of Muddy Creek (83,000 tons per year) times the number of years times the trap efficiency. Given the estimated capacity of Site C reservoir near Wolford Mountain, the present rate of sediment deposition would cause only a 10 percent reduction in capacity after 100 years.

Impacts and Mitigation Summary. Muddy Creek Reservoir operations would eliminate the conservation pool during an extremely dry period such as 1977. The impacts would occur primarily in the aquatics and recreation areas which are discussed separately in this chapter. There would be a shortfall of about 3,000 acre-feet in meeting the water delivery requirements of the Metro Denver Lease during this dry period. The shortage could be eliminated by reducing the amount of water obligated under the Lease.

The impact of the project on the town of Kremmling would be the risk of dam failure. A portion of the town would be inundated as a result of reservoir failure. The Colorado State Engineer requires frequent inspection, monitoring, and an emergency preparedness plan for each reservoir

constructed in the state, which would limit and mitigate this impact. Reservoir sedimentation should not impact the project since storage capacity would be reduced only 10 percent in a 100-year period. Deposition of sediment in the reservoir should not impact the stability of the downstream channel. Muddy Creek is controlled by short reaches of gravel or cobble armor and an adequate supply of fine-grained sediments would be available from the contributing watershed below the proposed dam.

4.4.3.4. Hydrology of Other Streams. To support impacts assessment for the proposed Muddy Creek project, effects of streamflows were analyzed on the main stem of the Colorado River at the Kremmling gage immediately upstream of Gore Canyon and at the Dotsero gage immediately downstream of the Eagle River confluence. In addition, an analysis was made of the effects of the project on the Blue River below Green Mountain Reservoir. Using 1962 to 1982 hydrology and proposed future development schedules, the effects of reservoir operations were analyzed for the Metro Denver Lease scenario (see Section 4.3.3.1).

The effects of the proposed Muddy Creek project were analyzed based on the difference in flows from the base condition of the 22,800 acre-feet sales level as simulated in the Green Mountain EIS (see Section 3.4.1.3). Details of the analysis along with assumptions behind the various calculations are summarized in a hydrology technical report available as a separate document (Resource Consultants, Inc., 1987a). Presented below is a brief description of the summary tables developed as a result of the analysis. Monthly discharge summary tables for all gaging stations are presented in Appendix A. As with Rock Creek operations, the largest change in flow occurs between the simulated base and historic flow conditions. The change between the simulated project flows and the simulated base condition is comparatively minor.

Colorado River at Kremmling. A comparison of the annual Colorado River flow in acre-feet at Kremmling for historic conditions, project baseline, and total project flows is shown in Fig. 4.4.3.7 for the Metro Denver Lease. Table 4.4.3.4 summarized the annual historic flows, base condition flows, and the simulated project flows with the Muddy Creek project. There is little effect at Kremmling since water sales which occur upstream of Kremmling would be replaced where Muddy Creek enters the main stem of the Colorado River above the Kremmling gage and above Gore Canyon. Effects of reservoir filling would be seen at the Kremmling gage and would affect Gore Canyon flows.

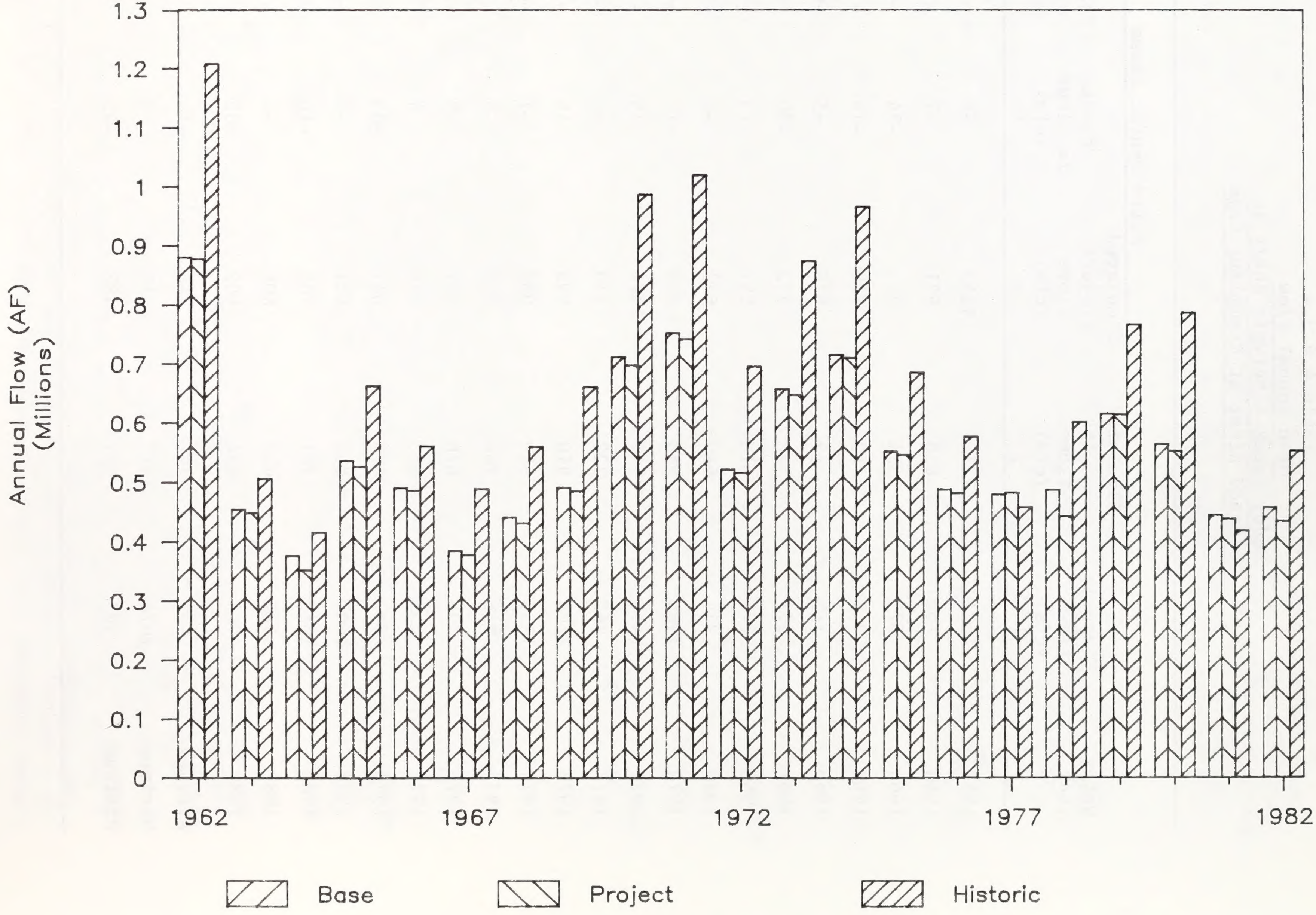
Column 1 of Table 4.4.3.4 is the historic average monthly flow in cfs as measured at the USGS gaging station. Column 2 is the simulated monthly flow for the base condition of the recommended 22,800 acre-foot sales level for the Green Mountain EIS. The large difference between column 1 and column 2 is a result of the assumption that existing water diversions through Roberts Tunnel and Windy Gap are exercised to their allowable legal capacity (significantly greater than their historic diversions). Column 3 presents simulated flows based on the Rock Creek Reservoir operations and column 4 is the difference from the simulated base condition. Column 5 is the percentage change in the base condition as a result of the Muddy Creek project.

Table 4.4.3.4
Mean Annual Flow
Muddy Creek Reservoir Analysis
Colorado River at Kremmling Gage

Water year	Historic flows (cfs) 1	Simulated baseline flows (cfs) 2	Metro Denver Lease: Simulated project flows (cfs) 3	Metro Denver Lease: Change in flows (cfs) 4	Metro Denver Lease: Percent change 5
1962	1671	1217	1213	-4	-0.33
1963	700	628	621	-7	-1.18
1964	575	521	487	-34	-6.50
1965	917	742	728	-14	-1.88
1966	775	679	673	-5	-0.81
1967	677	532	522	-10	-1.85
1968	775	610	597	-13	-2.10
1969	914	680	672	-8	-1.11
1970	1365	985	965	-19	-1.97
1971	1410	1042	1026	-15	-1.44
1972	962	722	715	-7	-1.00
1973	1208	910	895	-15	-1.63
1974	1335	989	982	-7	-0.71
1975	948	764	755	-9	-1.14
1976	798	676	667	-9	-1.34
1977	633	663	668	4	0.64
1978	832	675	612	-63	-9.29
1979	1061	852	851	-2	-0.20
1980	1088	781	765	-16	-2.02
1981	580	615	606	-9	-1.48
1982	765	634	602	-32	-5.11
Average	952	758	744	-14	-1.8
Maximum	1671	1217	1213	4	0.6
Minimum	575	521	487	-63	-9.3

Fig. 4.4.3.7. Simulated Colo. R. Flows At Kremmling

Muddy Creek Res. – Metro Denver Lease



Colorado River at Dotsero. A comparison of the annual Colorado River flow in acre-feet at Dotsero for historic conditions, project baseline, and total project flows is shown in Fig. 4.4.3.8 for the Metro Denver Lease. Table 4.4.3.5 presents the changes in flows that would occur at Dotsero as a result of the Muddy Creek project. At the Dotsero gage the effects of Muddy Creek Reservoir operations would be similar to the effects at Kremmling. Metro Denver Lease exchanges would occur upstream of the gage and therefore are replaced downstream of the Muddy Creek confluence. Columns in the table are the same as in the previous table for Kremmling.

Blue River. A similar analysis was completed for the Blue River below Green Mountain Reservoir for the Metro Denver Lease. A comparison of the annual Blue River flow in acre-feet below Green Mountain Reservoir for historic conditions, project baseline, and total project flows is shown in Fig. 4.4.3.9. It should be noted that the figures and tables in this section are identical to the Blue River figures for Rock Creek (Section 4.3.3.4). Table 4.4.3.6 summarizes the changes of flow developed in this analysis. Water sales and exchanges would occur above Green Mountain Reservoir which would account for the depletion to the Blue River. Because of diversions through the Roberts Tunnel above Dillon Reservoir, the Blue River below Dillon will experience fewer periods of flows which exceed the minimum 50 cfs release from Dillon. Again, the columns of Table 4.4.3.6 are the same as previously described. A summary of the impacts of Muddy Creek operations averaged over the period of record at the three gaging stations is presented in Table 4.4.3.7.

Impacts and Mitigation Summary. The Metro Denver Lease would result in diversion of approximately 11,000 acre-feet of water annually from the Colorado River basin with out-of-priority diversions being met by reservoir releases. Project impacts on surface water resources of other streams would be limited. The Blue River below Dillon Reservoir would experience fewer periods of flows which exceed the 50 cfs minimum release from Dillon. Impacts on recreational resources and aquatic biology are discussed in separate sections of this chapter.

4.4.3.5. Water Quality

Muddy Creek. Anticipated water quality impacts may be examined as three separate items: construction phase, reservoir area, and downstream area.

Construction Phase. The impacts to water quality from the construction phase are largely related to sediment production and water quality concerns from the use of heavy equipment near surface waters and the stream channel. Principal activities that may impact water quality include stripping topsoils and exposing subsoils, gravel mining operations in and around the live stream and the potential compaction of soils by construction machinery resulting in reduced infiltration rates.

Fig. 4.4.3.8. Simulated Colo. R. Flows At Dotsero

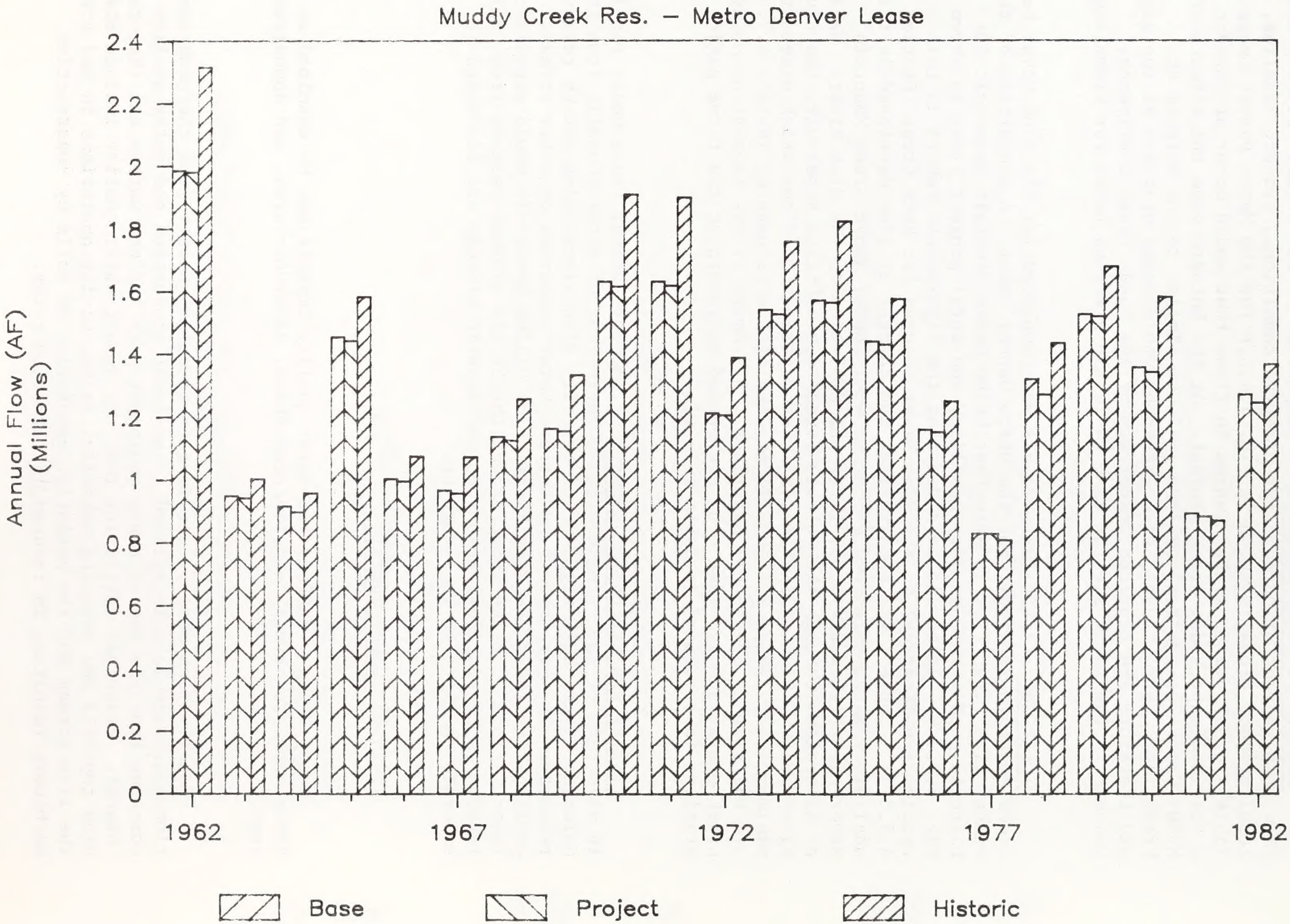


Table 4.4.3.5
Mean Annual Flow
Muddy Creek Reservoir Analysis
Colorado River at Dotsero Gage

Water year	Historic flows (cfs) 1	Simulated baseline flows (cfs) 2	Metro Denver Lease: Simulated project flows (cfs) 3	Change in flows (cfs) 4	Percent change 5
1962	3200	2745	2737	-7	-0.27
1963	1388	1314	1303	-11	-0.82
1964	1325	1269	1243	-26	-2.02
1965	2188	2012	1995	-17	-0.87
1966	1487	1388	1379	-9	-0.64
1967	1484	1337	1324	-13	-1.00
1968	1740	1573	1557	-16	-1.03
1969	1846	1610	1599	-11	-0.68
1970	2638	2256	2234	-23	-1.00
1971	2625	2255	2237	-18	-0.81
1972	1921	1679	1668	-11	-0.63
1973	2430	2130	2113	-18	-0.84
1974	2519	2171	2161	-10	-0.47
1975	2177	1990	1978	-12	-0.61
1976	1728	1604	1592	-13	-0.78
1977	1117	1144	1145	0	0.01
1978	1983	1824	1758	-66	-3.64
1979	2320	2110	2101	-9	-0.43
1980	2186	1877	1857	-19	-1.02
1981	1203	1236	1222	-13	-1.07
1982	1891	1758	1722	-36	-2.04
Average	1971	1775	1758	-17	-1.0
Maximum	3200	2745	2737	0	0.0
Minimum	1117	1144	1145	-66	-3.6

Fig. 4.4.3.9. Simulated Blue River Flows

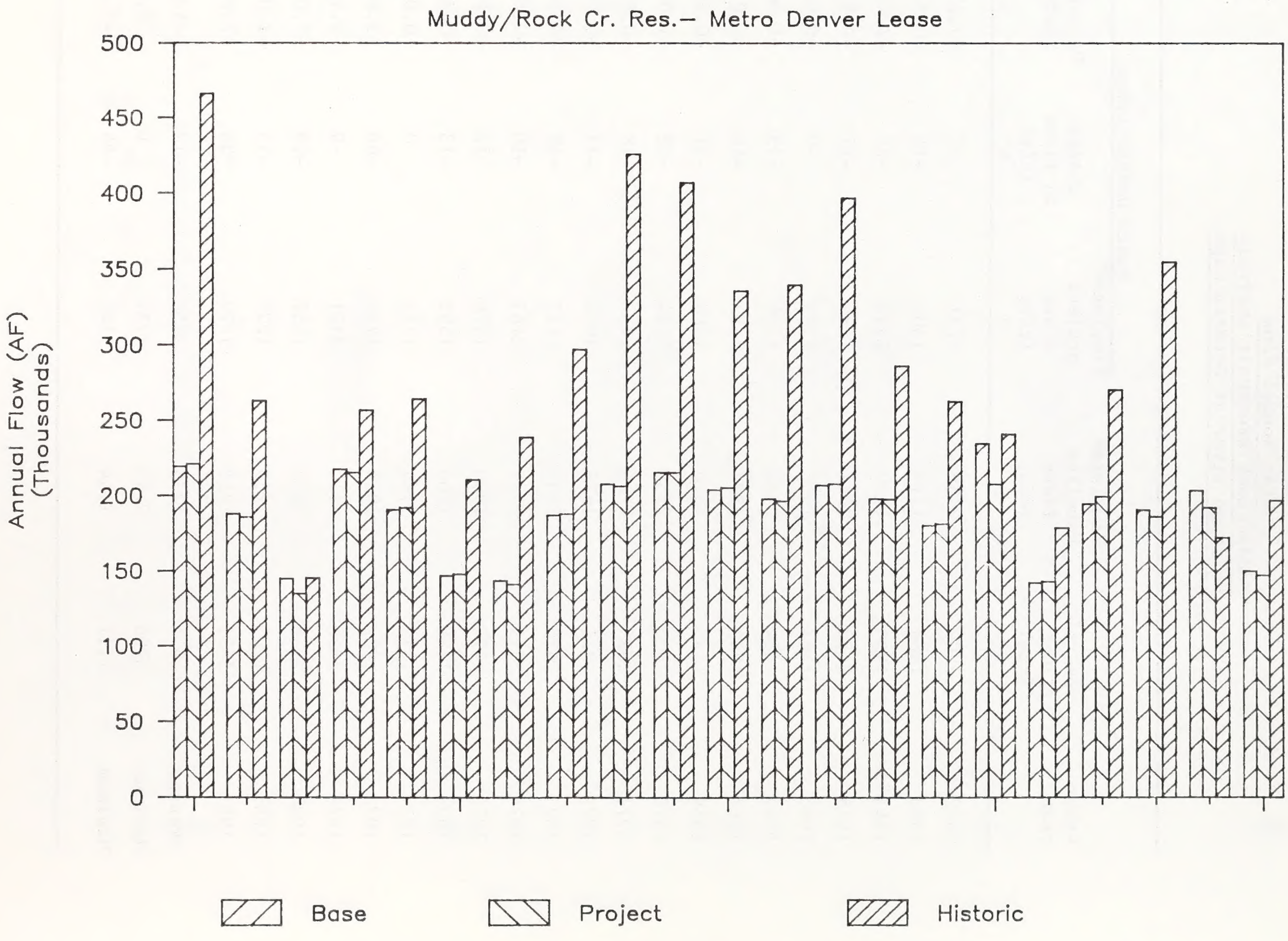


Table 4.4.3.6
Mean Annual Flow
Rock/Muddy Creek Reservoir Analysis
Blue River below Green Mountain Reservoir

			Metro Denver Lease		
Water year	Historic flows (cfs) 1	Simulated baseline flows (cfs) 2	Simulated project flows (cfs) 3	Change in flows (cfs) 4	Percent change 5
1962	644	303	305	2	0.73
1963	364	260	257	-3	-1.08
1964	201	200	187	-13	-6.69
1965	355	301	298	-3	-1.08
1966	365	264	265	2	0.58
1967	291	203	205	2	0.82
1968	330	198	195	-3	-1.64
1969	411	259	260	1	0.47
1970	588	287	285	-2	-0.77
1971	562	297	297	0	0
1972	464	282	284	2	0.79
1973	469	274	271	-2	-0.81
1974	548	286	287	1	0.40
1975	395	273	273	0	0
1976	363	249	250	1	0.50
1977	332	324	287	-37	-11.53
1978	247	196	197	1	0.68
1979	374	269	276	7	2.56
1980	490	264	257	-6	-2.34
1981	238	281	265	-15	-5.51
1982	272	207	203	-4	-1.88
Average	395	261	257	-3	-1.3
Maximum	644	324	305	7	2.6
Minimum	201	196	187	-37	-11.5

Table 4.4.3.7
Simulated Impact of Muddy Creek Reservoir
Operations for 1962-1982 Period

Location	Historic flow (cfs)	Base flow (cfs)	Metro Denver Lease: Simulated flow (cfs)	Metro Denver Lease: Change (cfs)	Metro Denver Lease: Change (%)
Blue River	395	261	257	- 3	-1.2
Kremmling	952	758	744	-14	-2.0
Dotsero	1971	1775	1758	-17	-1.0

Factors affecting sediment and other pollutants lost from construction sites include slope, proximity to the stream channel, vegetation buffer zones between the activity and channel, erodibility of soils, meteorological factors, length of time soils are exposed, and timing of activities with regard to the stream hydrology.

As with Rock Creek, the project contractor and subcontractors would be required to comply with applicable Federal, State, and local laws, regulations and permits concerning the control and abatement of water pollution. Construction activities would be performed by methods that would prevent entrance or accidental spillage of solid matter, contaminants, debris, and other pollutants into any water source. Such pollutants include, but are not restricted to, refuse, garbage, cement, concrete, oil and other petroleum products, and aggregate processing tailings.

During the construction phase, all contracts would specify that the contractor would provide and implement an erosion control plan that would comply with State Requirements for erosion control dams and with the Colorado Pollutant Discharge System permit. These include (1) using the minimum number of stream diversions possible, placed early in the construction period; (2) an undisturbed buffer zone 50 feet wide on each side of the channel; (3) excavated materials would not be stockpiled or deposited near streams or wetlands; (4) clearing of the reservoir would be done as late as the construction schedule would allow; and (5) to the maximum extent possible, equipment for instream construction would operate from the streambanks, rather than in the stream. See Appendix C for additional discussion of soil and water monitoring and erosion/sediment control. Following such procedures, no significant impacts to water quality would be anticipated during construction.

<u>Muddy Creek Reservoir</u>. Using the densimetric Froude number calculation (see Section 4.3.3.5), a reservoir on Muddy Creek would thermally stratify. Temperature data from Green Mountain Reservoir were obtained for assessing potential temperature regimes in Muddy Creek. Comparisons were inconclusive, but a reservoir in Muddy Creek would probably have similar freezing and melting times of the ice cover as Green Mountain Reservoir, that is, freeze-up in November and ice break-up in late April or in May.

Like Rock Creek, the eutrophication analysis is based on phosphorus being the most important factor limiting algal growth, thus phosphorus concentrations can be used as an indicator of trophic status. The phosphorus flux calculated for Muddy Creek was 3.9 Mg/yr or an areal phosphorus load of 0.85 $g/m^2/yr$ (see Table 3.4.11). Given normal reservoir operations, surface area and volume estimates were used to calculate a mean reservoir depth of 12 meters. The phosphorus loading and mean depth suggest that the reservoir waters have the potential of being eutrophic (Vollenweider, 1968). The Canfield-Bachmann model estimates phosphorus concentrations at 0.041 mg/L or slightly eutrophic to eutrophic (Canfield-Bachmann, 1981) (each model uses a different index) (Canfield-Bachmann, 1981). The data base and the results of water quality models used, coupled with warmer temperatures than Rock Creek, indicate that there could be a potential for water quality problems in Muddy Creek Reservoir.

The areal loads for nitrogen and phosphorus for the proposed Muddy Creek Reservoir are 9.68 $g/m^2/yr$ and 0.85 $g/m^2/yr$, respectively (Table 4.3.3.7). The P load is higher than either Dillon or Green Mountain reservoirs, yet the N load is lower. This may reflect the influence of man in the Dillon and Green Mountain watersheds. If phosphorus is the most important limiting factor in algal production, the proposed Muddy Creek Reservoir would have higher productivity than either Dillon or Green Mountain reservoirs. The proposed reservoir is at 7,490 feet (lower than Rock Creek) and would have warmer temperatures than Rock Creek. Nonetheless, cool water temperatures could restrict biological activity. Muddy Creek waters are usually turbid and may be warmed by solar radiation and increase productivity especially in coves or other quiet waters. Similar observations were made for the proposed Stagecoach Reservoir near Steamboat Springs (USDI/BR, 1986).

As with Rock Creek, Muddy Creek Reservoir would fluctuate in elevation annually, and planktonic growth would be more apt to be favored than littoral, especially in areas with steep banks or shorelines.

The reservoir would have increased nitrogen and phosphorus inputs, when initially inundated (as described for Rock Creek). Since there is less vegetation and soil organic matter than in Rock Creek, this input would be decreased accordingly. Again, no estimate of iron or manganese mobility was made, nor was their impact on dissolved oxygen kinetics assessed.

The higher nitrogen and phosphorus load in Muddy Creek coupled with warmer temperatures would allow greater primary productivity than Rock Creek and subsequently decrease water quality, especially if algal or planktonic growths develop.

For most reservoirs temperature, turbidity, and nutrients would be the most important three factors limiting biological activity. The average annual inflow for Muddy Creek Reservoir is 67,663 acre-feet and a storage of 46,800 acre-feet for a calculated detention time of 0.69 years. (For comparison, Green Mountain Reservoir has a detention time of 0.49 years.) Experience at other reservoirs shows that water temperatures and a short hydraulic detention time could limit any eutrophication potential (Ward, 1976).

Muddy Creek suspended sediment concentrations were variable with streamflow, but did exceed 3,000 mg/L. Average suspended sediment was 53 percent clay, 41 percent silt, and 6 percent sand. The suspended sediment load represents 97 percent of the 83,000 tons/yr erosion rate (Ruddy, 1986). Waters in the proposed Muddy Creek Reservoir have the potential to be turbid, since many of the shoreline soils will be subject to erosion from wind generated wave action. Turbid waters from sediment or algae may deter recreationists. Suspended sediment particles, especially as clay, could travel through the reservoir and be released in the outflow water, especially given the short detention time. Turbidity of the tailwater may not change appreciably, but suspended sediment concentrations could decrease, particularly in relation to the portion of the sediment load that is in the sand-size fraction (about 6 percent). Differences in temperature

and subsequent water density changes were not assessed for the reservoir. Such thermal stratification may further shorten the hydraulic detention time.

Muddy Creek below the Dam. Changes in streamflow below the dam may affect the water quality constituent concentrations that are flow related. The effect of altered streamflows may change the nutrient flux below the dam, however the natural variations are as large or larger than potential changes with the proposed dam. Potential changes in water quality below the dam are insignificant given the proposed operating schedule.

There would be no measurable changes in water quality or salinity in the Colorado River as a result of construction of Muddy Creek Reservoir. There are no measurable differences in water quality impacts between the proposed or alternate damsites. The short detention time of the reservoir, coupled with the high percentage of clay and silt in the suspended sediment load (80-90 percent), and the expected contribution of suspended sediment from the downstream watershed make it unlikely that the suspended sediment load below the dam would change significantly (see channel stability discussion--Section 4.4.3.2). The deposition of silts and clays in a reservoir is strongly influenced by sediment particle interactions and reservoir circulation patterns. Factors which determine circulation patterns include inlet and reservoir geometry, reservoir operations, density currents, and energy inputs (sun, wind). The assessment of potential impacts of Muddy Creek Reservoir on sediment conditions below the dam could be refined by modeling during the design phase and post-construction monitoring.

Impacts from temperature variations in the reservoir and from reservoir releases could be controlled with a structured multilevel outlet. Regulated releases could better control downstream temperatures for fishery resource management. Reservoir operations would deplete the reservoir volume in extreme dry years (see Fig. 4.4.3.4) and the temperature of outflow water would be controlled by inflow temperatures. In general, however, the reservoir hypolimnion volume should be sufficient to allow constant 4°C releases. Additional water quality monitoring can better determine temperature of released waters.

Mitigation. Water quality changes downstream and in the reservoir need to be better determined before specific mitigation can be proposed. Additional water quality monitoring and temperature and sedimentation modeling during the design phase and the early years of reservoir operation would better quantify the potential water quality and sedimentation changes.

4.4.3.6. Unavoidable Adverse Impacts. Given the potential water quality impacts indicated by the present water quality data base as well as other potential impacts which may be identified by the proposed water quality monitoring, the chemical and physical integrity of Muddy Creek may be affected. However, the limited data base at present will not allow quantification of these impacts as related to State water quality standards.

4.4.4. Ground-Water Resources

4.4.4.1. Anticipated Impacts. Changes to the ground-water resources of the Muddy Creek basin would be limited. Local changes in the ground-water table would be experienced as the reservoir fills and releases. Some increase in the water table could be experienced immediately downstream from the dam due to seepage.

4.4.4.2. Mitigation. No mitigation would be required for the impacts to the ground-water resource.

4.4.4.3. Unavoidable Adverse Impacts. There would be no unavoidable adverse impacts to the ground-water resource of the Muddy Creek basin.

4.4.5. Air Quality

4.4.5.1. Anticipated Impacts. Air quality impacts may occur from construction activity. Dust and smoke would be associated with the construction phase. Noise would also be a short-term impact. Secondary impacts to air quality may be generated from recreation parking areas, however the impact would not be significant. The occurrence of fogs in and around Kremmling could increase because of the presence of the water body and tailwater; but the potential cannot be quantified.

4.4.5.2. Mitigation. Appropriate mufflers and other exhaust filters would minimize most air quality impacts. Activity scheduling may be required during inversions or other inclement weather periods.

Measures would be implemented to reduce dust from such construction activities as travel on dirt and gravel roads, excavations, quarries, aggregate plants, and storage areas. Measures would include limiting such activities to the minimum area possible for the shortest possible period, use of dust suppressants, and revegetation. The contractor would furnish all labor, equipment, and materials required to control fugitive dust in compliance with Federal, State, and local regulations. Contractors would be expected to use such methods and devices as are reasonably available to control, prevent, and otherwise minimize noise, vehicle and plant emissions, and discharges of atmospheric contaminants.

4.4.5.3. Unavoidable Adverse Impacts. No unavoidable adverse impacts are expected on air quality.

4.4.6. Vegetation. See Section 4.3.6 for a general discussion on impacts that would occur as a result of construction and operation of a reservoir project.

4.4.6.1. Anticipated Impacts

General Vegetation

Inundation. Construction and operation of this dam site would result in inundation of approximately 1,200 acres, or 6 percent of vegetation in the 21,000 acre study area, at the normal maximum operating level. Of this total, approximately 393 acres of sagebrush complex, or 3 percent of the total for this type in the study area, and 807 acres of wetland, or 14 percent of the total for this type in the study area would be inundated. These losses are summarized in Table 4.4.6.1. Figure 3.7.3 shows the distribution of these types within the inundated area.

The usefulness of vegetation community types inundated and destroyed would be lost in terms of utilization by wildlife and range livestock, as well as utilization for outdoor recreation. The loss of the sagebrush complex type would not be significant since this type is common, of wide distribution and high frequency within the general area of the project. However, the loss of wetlands would be considered significant and is discussed in greater detail under Sensitive Species and Communities in this section.

Facilities Construction. Facilities that would be constructed in conjunction with the reservoir include the dam, spillways, borrow areas, primary access road, secondary access road, reconstruction of Highway 40, transmission line tower relocations, and recreation sites. Table 4.4.6.1 summarizes the denudation and disturbance of vegetation that would occur due to facilities construction.

Several borrow areas are planned in the vicinity of the dam site including one upstream of the dam site and one downstream of the dam site. Therefore, all but one site would be covered by the reservoir and would be included in the inundation impacts. It is assumed that approximately 40 acres of sagebrush complex would be denuded at the borrow area site below the proposed dam.

No specific plans have been formulated for one or more recreation sites at the reservoir. It is assumed that facilities of similar size to the Rock Creek campground and day use facilities would be developed at this reservoir site. Most or all of this development would occur in the sagebrush complex type in an area comparable to the Rock Creek facilities of 40 acres. For purposes of comparison, it is assumed that a greater intensity of development would occur within the 40 acres at Muddy Creek than at Rock Creek resulting in the loss of 10 acres of sagebrush complex.

Weedy exotic plant species may invade the areas disturbed by facilities construction. The probability of a significant problem developing as a result of the establishment of such species would be moderate to high.

Table 4.4.6.1. Summary of vegetation impacts by wetland type (loss in acres) due to inundation and facilities construction for the Muddy Creek dam site.

Community Type	Project Component				Summary		
	Inundation	Dam (including spillways)	Roads	Recreation Facilities	Total Affected	Total In Study Area	Percent of Total in Study Area
Uplands							
Sagebrush complex	393	7.0	15.0	10	465	15,535	3
Percent of total lost	3	<1	<1	<1	100	--	--
Wetlands							
Naturally Subirrigated wet meadow	590	2.5	0.5	0	593	3,208	19
Artificially irrigated meadow	154	0	0	0	154	1,150	13
Willow riparian	36	0	0	0	36	442	8
Cottonwood riparian	3	0	0	0	3	23	13
Fast moving stream	15	0.5	0	0	15.5	154	10
Slow moving stream	1	0	0	0	1	5	20
Ponds and standing water	0	0	0	0	0	47	0
Standing water with floating rooted vascular plants	7	0	0	0	7	11	64
Standing water with cattails	1	0	0	0	1	1	100
TOTAL WETLANDS	807	3	0.5	0	810.5	5,041	16
Percent of total wetlands lost	99	<1	<1	0	100	--	--
TOTAL VEGETATION	1,200	10	15.5	10	1,275.5	21,000	6
Percent of total vegetation lost	94	<1	1	1	100	--	--

Sensitive Species and Communities. No federally listed plant species would be impacted by the Muddy Creek site alternative. Of the sensitive plant species itemized in Table 3.7.4, only Osterhout's milkvetch and cyathophorus penstemon would be impacted. Field surveys and existing information indicated that the other species do not occur in areas that would be directly impacted by construction and operation of this alternative.

Osterhout's milkvetch grows in concentrated populations on highly seleniferous soil on the terraces primarily on the west side of Muddy Creek, but also in one small population on the east side (Fig. 3.7.3). Portions of the main populations are distributed topographically below the central portions of these populations, apparently as a result of the erosion and subsequent deposition of the seleniferous soil and seeds down into small washes. These portions of the populations are generally small in areal extent and numbers, but occasionally have moderately dense stands of individuals. Based on a field survey and previously compiled information, approximately 132 acres of habitat containing populations of the milkvetch occur in the immediate vicinity of the proposed reservoir site. Of this total, approximately 82 acres, or 62 percent, occur on BLM administered land and 50 acres, or 38 percent, on privately owned land.

The high water level of the proposed reservoir was level-surveyed in the vicinity of Osterhout's milkvetch populations in June 1987 and the portions of these poopulations that would be inundated were determined. Of the main populations that occur in the area, only the small population on the east side of the reservoir (see Fig. 3.7.3) would be totally inundated. On the west side of Muddy Creek, only the margins of major populations would be impacted. The individuals impacted occur in marginally suitable habitat in small washes below the central populations as described above. Based on the survey conducted in June 1987, over 1,000 individual plants would be inundated in total. Of this total, about 800-900 individuals would be lost in approximately 5 acres of good habitat as defined by areas with fairly dense populations. In addition, approximately 5 acres of fairly marginal habitat as defined by scattered, low numbers of milkvetch, would also be inundated, accounting for the remaining 100-200 individual plants. Fig. 3.7.3 shows the locations of these populations along the shoreline of the normal maximum operating level of the reservoir. It is estimated that the loss of 1,000 individual plants would represent approximately 8 percent of the total number of individuals in the vicinity of the Muddy Creek Reservoir.

During flood periods when the reservoir would rise 8 to 10 feet, additional numbers of plants would be inundated. The inundation at flood stage would be short term and would not significantly impact the species except at the shoreline where wave action could erode soil and dislodge plants.

In addition to loss of habitat and individuals of the species due to inundation, the species could be impacted by perennial soil saturation in response to a rise in the water table induced by the filling of the reservoir. However, the magnitude and extent of such a projected impact is not known. The species would also be directly impacted by the proposed trans-

mission line tower relocation on the east side of Muddy Creek. A small population was identified at the base of the tower proposed for relocation.

Indirect impacts to the species would include destruction of habitat and individuals as a result of recreation development and increased use of the area adjacent to the reservoir shoreline due to trampling by humans and vehicles, as well as land clearing. As an example, according to Chuck Cesar (1987) of the BLM in Kremmling, Grand County has developed preliminary plans for recreation development in areas on the west shore of the reservoir that contain the milkvetch. This development would significantly impact the species. If access to the reservoir shoreline in the immediate vicinity of known populations was not controlled, increased use of the area by vehicles could significantly impact the species.

Cyathophorus penstemon is very sparsely distributed throughout the sagebrush complex type at the reservoir site. Thus, any inundation of and disturbance in this type could impact the species through loss of habitat and loss of individuals. However, since the species is so sparsely distributed in the area, it is doubtful that the total approximate loss of 465 acres of sagebrush complex would result in significant impact to the species. Although not specifically surveyed for, Penland's penstemon was not observed to occur in the immediate environs of the Muddy Creek project. Therefore, it is doubtful that the species would be significantly impacted. Similarly, the other rare species listed in Table 3.7.4 would not be impacted since they occur out of the immediate vicinity of this alternative.

Approximately 810 acres, or 16 percent of the total 5,041 acres of wetland in the study area would be lost due to inundation, construction and operation of this alternative. Table 4.4.6.1 summarizes loss or destruction of wetlands due to construction and operation of this alternative. Figure 3.7.3 shows the type and distribution of wetlands that would be destroyed. Inundation would create the largest loss of 807 acres. The most significant loss would occur to the wetland types that are relatively rare in the study area, including 11 acres, or 64 percent, of standing water with floating rooted vascular plants, and 1 acre, or 100 percent, of standing water with cattails.

Most of the 593 acres of wetlands lost belong to the naturally subirrigated wet meadow category (Figure 3.7.3). A majority (approximately 450 acres) are either presently hayed, were previously hayed, or used as pasture, and therefore, have been influenced by man through irrigation, introduction of non-native vegetation for hay, and through grazing the wetland areas. Those portions of the wetlands that are grazed are in poor condition. No measurements are available that quantitatively show the effect of overgrazing, but observations during field studies for this EIS indicated much of the grasses are utilized down to only a few inches, shrubs are heavily browsed, and several vegetation species which are not characteristic of wetlands are invading areas that have not been irrigated for some time. In addition, approximately 150 acres of artificially irrigated meadow would be lost. Therefore, about 207 acres of excellent wetland, and about 450 acres of man-affected wetlands would be lost by the proposed project.

In addition to the loss of existing wetlands, approximately 1,200 acres of open water wetland (Palustrine Littoral Unconsolidated Bottom) would be created.

The loss of 810 acres of existing wetlands would constitute a significant impact since wetlands are unique, cover relatively small areas, have low frequencies in the area, and present unique and important wildlife habitat.

Wetland vegetation would not pioneer the shoreline of the reservoir since the water level would continually fluctuate. Pioneering vegetation requires relatively stable environmental conditions that would not be provided by a fluctuating water level and shoreline.

Streamflow regulation would slightly alter the flow regime of Muddy Creek below the dam. Because quantity and distribution of streamside vegetation are a function of flow regime, an alteration of this flow could affect the riparian and wetland vegetation. Reduction in yearly high flows would probably reduce bank cutting and allow riparian vegetation to expand and stabilize the streambanks. This increase in riparian vegetation would only involve a few acres and would be considered a beneficial impact.

4.4.6.2 Mitigation. The denudation of upland vegetation during construction of the dam and associated components would be mitigated through the successful implementation of a site-specific revegetation plan as part of the runoff, erosion, and sedimentation control plan described under Water Quality (Section 4.4.3.5) and in Chapter 5.

The destruction of Osterhout's milkvetch populations and habitat may be mitigated by constructing dikes which would protect the areas containing the species from inundation. The necessity and extent of application of such a measure would be determined prior to the completion of the FEIS by accurately level surveying the reservoir shoreline in the vicinity of the areas containing the species to determine the actual losses of the species that would occur. If it is determined that a relatively small portion of populations would be inundated, transplanting of individuals into habitat not impacted by the project could be implemented to minimize impacts to the species. The populations of the milkvetch in close proximity to the reservoir would be fenced to prevent or minimize trampling by vehicles and recreationist foot travel, and by cattle. Recreation site development would not be allowed on areas containing the species. These measures are described in greater detail in Chapter 5.

Mitigation of wetland losses due to dam construction and reservoir operation could be accomplished in two general ways: 1) creation of new wetlands; or 2) improvement and rehabilitation of existing wetlands in poor condition. Creation of new wetlands would be difficult since areas with conditions required by wetland vegetation are very limited in the general vicinity of the reservoir site and are generally already exploited by wetland vegetation.

Mitigation of wetland values (i.e., wildlife habitat units) by improving and rehabilitating existing wetlands would be more feasible than creation of new wetlands. Several watershed areas were studied with respect to improving the existing wetland value to mitigate losses at the Muddy Creek site. The mitigation plan as presented in Chapter 5 details the measures that would be implemented at these watersheds to improve wetland value and consequently fully mitigate the loss of wetland values.

4.4.6.3. Unavoidable Adverse Impacts. With respect to wetland vegetation and wildlife values associated with those wetlands, the mitigation plan presented in Chapter 5 would mitigate all the losses that would occur due to the implementation of this alternative. Therefore, no unavoidable adverse impacts would remain. Since vegetation would probably take several years to become fully established, there could be a short-term loss for these years.

With respect to Osterhout's milkvetch, the mitigation plan presented in Chapter 5 would mitigate most or all of the impacts that would occur to the species as a result of implementing this alternative. Therefore, few if any unavoidable impacts to the species would remain.

4.4.7. Aquatic Biology

4.4.7.1. Anticipated Impacts

Muddy Creek. The alteration of several miles of Muddy Creek by a reservoir and changes in flow characteristics of several more miles would greatly alter the aquatic ecosystem utilizing the river. The present fish community is composed of non-game suckers and minnows, none of which are considered particularly rare or of special concern. The stream does not even provide very good habitat for those species. Therefore the alteration of Muddy Creek by a reservoir, and by altered flows below the dam, would not be a significant adverse impact to aquatic biology.

In fact, the stream below the proposed dam would probably be somewhat clearer and cooler, providing better habitat than the existing situation. The IFIM analysis (Holden and Hardy, 1986) indicated that habitat conditions in the present stream would support trout, with turbidity and perhaps temperature being the present limiting factors. In fact, the amount of habitat would be fairly high, in between the amount available at Station 3 and 4 on Rock Creek (Table 4.3.7.1), if the stream banks were stabilized with overhanging vegetation as would occur with the proposed wetlands and wildlife mitigation (see Chapter 5). It is suspected the clearer releases from the dam would improve the substrate conditions by removing some of the finer (silt) particles for about the first 9 miles below the dam. More constant releases would aid in establishing streambank vegetation, which would improve habitat conditions and reduce stream siltation.

Therefore, habitat conditions below the dam could improve sufficiently that a cold water trout fishery could be established. Stocking of rainbow trout would provide an instant fishery below the dam. The major problem that could prevent a decent tailwater fishery would be turbidity. As discussed in the Water Quality section, much of the sediment that would enter the reservoir could stay in suspension and be released downstream. How much is not known and the actual clarity of the released water is not known. Therefore, the tailwater fish potential could be substantially reduced by turbidity. Public access below the dam would be excellent since within the first 9.5 miles below the dam, 1.5 miles is State land, and 4.0 miles is BLM land. Therefore, the Muddy Creek reservoir could result in a beneficial impact to stream fisheries by creation of a cold water fishery where none existed before, but potential problems with turbidity could reduce the quality of the fishery considerably.

Muddy Creek Reservoir. As with Rock Creek, the creation of a reservoir on Muddy Creek would provide opportunities for reservoir habitat and fish populations, a beneficial impact. The two models discussed under the Rock Creek alternative were also used to evaluate the proposed Muddy Creek reservoir. The Habitat Suitability Model (McConnell et al., 1982) indicated that Muddy Creek would probably have a low to medium quality stocked rainbow trout fishery. The major detrimental factor was the potential for poor water clarity. The Reservoir Quality Index indicated that the reservoir would produce a moderate to good fishery.

Nutrient availability in the proposed reservoir would be fairly similar to Green Mountain Reservoir, with slightly more phosphorus. Muddy Creek would fluctuate less than Green Mountain, usually only about 10 feet per year. But it could be drawn down to nearly dry once in a 21-year period of record (Fig. 4.4.3.4). This would seriously impact the fishery that had developed and suggests a put-and-take fishery would be the best management of the reservoir. Muddy Creek reservoir may be too productive or too turbid to produce fish at the rate of Green Mountain. Muddy Creek would spill during June of most years (see Appendix A) during runoff, and turbidity would be high also during these months. It is not known how turbid the reservoir would be other times of the year, but it could be sufficiently turbid to reduce its potential as a trout fishery. Therefore, Muddy Creek reservoir has the potential to become a moderate or better fishery, a beneficial impact, but that potential may be overshadowed by water clarity problems.

Other Areas. Colorado River - The Wild Trout Water between Gore Canyon and State Bridge would be affected by an alteration of flows as shown in Appendix A. An IFIM analysis of the station measured in that reach indicated that brown trout habitat would not be affected negatively by more than five percent except during one runoff period in the 21 year period of record (Fig. 4.4.7.1). As discussed for Rock Creek, habitat during runoff is in access based on flow, and its reduction would not be a negative impact. During most months of most years, habitat would actually be improved with increased flows (Figure 4.4.7.1), but increases would surpass 25 percent, a level considered significant, only in 3 months in the

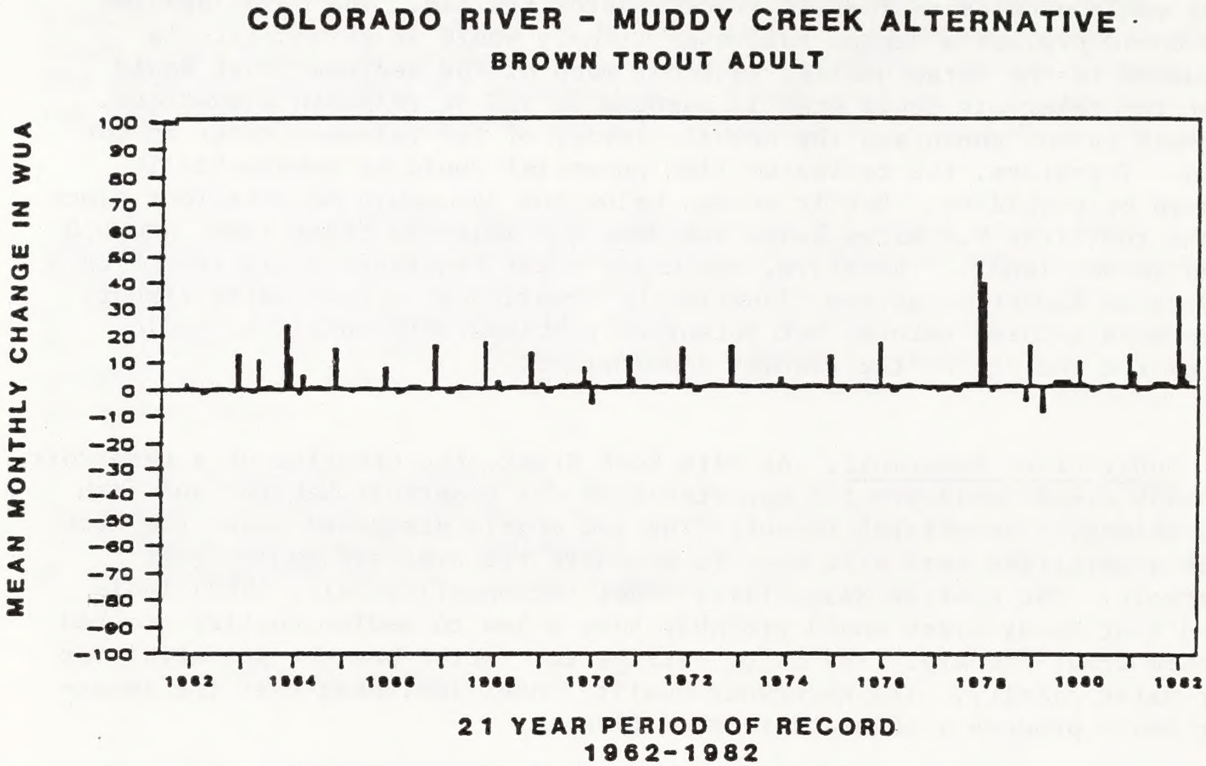


FIGURE 4.4.7.1. Percent change in mean monthly WUA for the IFIM analysis for the Colorado River in Gore Canyon for Muddy Creek Reservoir.

21-year period of record. The reason for this habitat change is that WUA for adult brown trout decreases with flow in the Colorado River (Holden and Hardy, 1986), and the proposed project would generally reduce flows in the Colorado River most months. Therefore, Muddy Creek Reservoir would not negatively impact the Gore Canyon fishery and would improve trout habitat slightly.

Flow alterations would continue downstream in the Colorado River and slowly dampen out as the river receives other inflow. No impacts to game or nongame fish species is expected since the amount of flow change is not dramatic and the fish in these areas generally live in a large range of flow conditions.

Blue River - Changes in monthly flow in the Blue River below Green Mountain would be exactly as discussed for Rock Creek. No significant negative impacts would occur and beneficial impacts could occur.

Sensitive Species. Impacts to rare fishes in the Colorado River would be very similar to those discussed for the Rock Creek Alternative. Flow depletion would be the major concern. Appendix A shows the types of alterations of flow that would occur for East Slope sales scenario. Depletions greater than 5 percent of simulated flows would only occur during runoff months. Therefore, by itself, Muddy Creek Reservoir would not impact the rare fish.

Alternative Dam Site. The selection of a damsite downstream from the proposed site would cause a negative impact in that less tailwater would be available to develop a fishery. However, a move of only about a quarter mile would not be significant.

4.4.7.2. Mitigation. No significant adverse impacts would occur so mitigation would not be necessary. In fact, impacts would be beneficial overall to fishery resources.

4.4.7.3. Unavoidable Adverse Impacts. No unavoidable adverse impacts would occur.

4.4.8. Wildlife

4.4.8.1. Anticipated Impacts. Anticipated primary impacts to wildlife occurring as a result of developing the proposed reservoir at the Muddy Creek site fall into three general categories: 1) disruption of wildlife use of the area during construction and operation of the reservoir; 2) direct loss of existing habitat by inundation; and 3) creation of lacustrine habitat and establishing populations of its associated species.

Impacts Associated with Construction and Operation. Elk and deer primarily use the area of concern for winter range. Since construction activities would occur in spring and summer, disturbance would not be expected to disrupt big game use. Roads needed for reservoir development and access and new recreation facilities would impact about 80 acres of upland habitat which is big game winter range. The loss of winter range is a significant impact and is manifested in several ways discussed below.

Impacts Associated with Inundation. Several aspects of the inundation of a substantial portion of the Muddy Creek big game wintering area contribute to causing a significant impact to big game using the area. Some of the impacts described below are likely to be significant even when considered on an individual basis, collectively they would definitely be significant. The types of impacts likely to occur consist of direct loss of winter habitat, physical barriers to movement, ice hazards, highway hazards and depredation on local hay stacks.

The loss of 1200 acres of big game winter habitat through inundation and associated reservoir facilities would have a significant affect on elk and mule deer. All elk and mule deer winter ranges are considered critical habitat by CDOW (Olsen, 1987). Winter ranges for big game ungulates have been previously described in Section 3.9.2.1. Table 4.4.8.1 summarizes the winter range in various categories that would be significantly affected under the No Action and Muddy Creek Alternatives within the study area. Loss of winter range could have a significant affect on elk and mule deer populations by increasing intra- and interspecific competition for forage, decreasing the quality of forage, changing the daily movement of individuals, and loss of microhabitat that provides shelter during severe weather. These factors may result in increased winter mortality due to starvation, physiological stress and highway mortality. Increased physiological stress and nutritional deficiencies may also result in a subsequent loss of recruitment to populations.

The proposed reservoir would pose a physical barrier to big game movement, both diel and migratory. Under the present scenario (No Action Alternative) big game west and north of the study area migrate into the area to reach traditional winter range in the project area and farther east.

Daily winter activity patterns for elk and mule deer include movements across the proposed project area to reach areas for foraging and cover. The lower third of the proposed reservoir would affect a major deer migration route; the upper half of the reservoir would affect deer and elk migration routes. Since the reservoir would lay perpendicular to traditional corridors, it would create an obstacle to traditional movements. Disruption of big game migration and movement within the winter range would be a significant impact.

Ice on the reservoir may pose a hazard to big game. If big game animals crossed the reservoir when ice was thin they may break through suffering injury or death. Also, big game could be more susceptible to harassment by coyotes and dogs when crossing the ice. Elk and deer can

Table 4.4.8.1

Big Game Winter Ranges Within the Muddy Creek Study Area Under No Action and Muddy Creek Alternatives

Species	Scenario	Winter Range (Ac)	Winter Concentration Area (Ac)	Severe Winter Range (Ac)
Elk				
	No Action[1]	21,600	10,012	10,565
	Reservoir[2]	20,328	8,969	9,637
	Net Loss	1,276	1,043	928
	Percent of Total	5.9	10.4	8.8
Mule Deer				
	No Action	21,600	6,193	4,939
	Reservoir	20,328	5,545	4,735
	Net Loss	1,272	648	204
	Percent of Total	5.8	10.5	4.1

[1] No Action is the present condition of the study area without the reservoir construction.

[2] Reservoir indicates condition of the study area after reservoir construction.

easily fall and be injured or caught by coyote or dogs on ice, especially if little or no snow is on top of the ice. Losses incurred because of ice hazards are difficult to predict but could represent significant direct mortality to deer and elk populations.

The reservoir obstacle may result in an increased number of big game animals remaining on the west side of the reservoir with subsequent daily movements relegated to the west shore and east across Highway 40. This section of road currently incurs high vehicle/big game collisions (20-40 mule deer/year) and an increase in daily movements across this highway would undoubtedly amplify the mortality rate. In addition, if big game could not easily travel from the west to the east banks of the Muddy Creek drainage, they may be more apt to depredate the hay stacks found to the west or north of the proposed reservoir. The losses resulting from the physical presence of the reservoir would augment the significant affect to big game attributable to the displacement of winter range by the reservoir.

Another significant impact attributable to inundation would be the loss of approximately 810 acres of wetland habitat types and their associated wildlife values. The importance of this impact is based on the potential capacity of wetlands as biological resources, the relative scarcity of wetlands in the study area and the variety of wildlife species that need these resources to fulfill part or all of their life requisites. Wildlife utilize wetland, especially riparian areas, disproportionately more, both in terms of species numbers and densities, than the surrounding upland habitat types (Hoover and Wills, 1984). Specific acres of the various wetland types involved were presented in the Vegetation section of Chapter 4.

Wildlife values for the acreages lost through reservoir development were analyzed with Habitat Evaluation Procedures (HEP) analysis. Habitat Units (HUs) were derived by first determining the Habitat Suitability Index (HSI) for a given area and species. The species selected are taken to be indicators of the habitat parameters that are deemed important and do not by themselves necessarily reflect a value. The HSI was multiplied by the number of acres of habitat for the indicator species within the area proposed for inundation to obtain HU's (Table 4.4.8.2). A separate report (Pekins and Hugie 1986) details the HEP conducted at Muddy Creek.

Table 4.4.8.2

Loss of Wildlife Values Associated with Inundation of Wetland Habitats and Big Game Winter Range at the Proposed Muddy Creek Reservoir Site

Indicator Species	Associated Habitat Type	Habitat Units Affected
WETLANDS		
Elk	Wet meadow Willow riparian	305
Beaver	Willow riparian	18
Yellow warbler	Willow riparian	13
Big Game Winter Range		
Elk	Sagebrush association	194
Mule deer	Sagebrush association Willow riparian	295

Some waterfowl and shorebird nesting occurs within the study area, although nesting is not extensive. Inundation would displace nesting birds; however, their propensity to renest at alternative sites is high, and productivity is not expected to decrease due to disturbance. Loss of

waterfowl production is one of the impacts associated with loss of wetland habitats. Considered individually however, it is considered an adverse but insignificant impact.

The most important upland game bird using the study area, sage grouse, would be disturbed on its summer range but no leks would be impacted. Because sufficient rearing and summer habitat is available throughout the area loss of this type of habitat is not considered a significant impact.

Although several species of raptors are known to nest within the general area, no active nests are known to exist within the inundation zone or near an area that would be frequently disturbed such as a major access road or recreation site. Loss of small mammals due to inundation would not affect the prey base for raptors since these prey species are common within the general area and many alternative foraging habitats are readily available. Winter residents, such as golden eagles, would be disturbed by increased winter access to the area; however, because of their mobility, availability of remote roost sites and extensive foraging habitat, disturbance would not significantly disrupt their daily or seasonal use of the area.

In many places Muddy Creek has deeply incised the flood plain creating high banks that are used by cavity-nesting birds that normally use large trees. Since these individuals are already utilizing alternative nest sites, loss of these high stream embankments would further decrease nesting potential for many of these species. This would be an adverse but insignificant impact.

Creation of Lacustrine Habitat. Reservoir development would create a 1,272 acre lacustrine environment replacing the riverine environment that would remain under the No Action Alternative. This may increase waterfowl use of the area for production and would offer resting and loafing areas. Fluctuations in water levels would hinder the establishment of extensive shoreline vegetation necessary for foraging and perhaps nesting waterfowl. However, nesting habitat will remain adjacent to the proposed reservoir and the lacustrine environment would provide some habitat for rearing waterfowl. Additionally, the reservoir would provide a migratory stopover for waterfowl and shorebirds. These are all positive impacts.

In summary, the collective impacts to big game include displacement from an area used as winter range, placement of a major obstacle within known movement corridors which may contribute to forms of mortality such as vehicle collisions and depredation management actions, ice hazards, and an increase in general stress associated with disturbance and other factors. These are considered significant as a whole and in some cases individually. The other significant impact is the loss of wildlife values associated with the loss of about 810 acres of various types and classes of wetlands. Impacts to upland game, waterfowl, raptors and general wildlife were considered adverse in some cases, but not significant.

Secondary Impacts. Secondary impacts would be caused by increased recreation and other activities within a mile of the reservoir. Several sage grouse leks could be disturbed during the breeding season from such activity, this could be a significant impact. Similarly, several raptors nest within a few miles of the reservoir, disturbance from recreationists or others associated with using the reservoir could cause nest abandonment or other types of mortality. This would be significant if it occurred. ATVs operated along the shores of the reservoir could cause habitat deterioration and further affect big game that depend on a healthy environment. This would add to an already significant impact. Excessive snowmobile use of the reservoir could disturb wintering big game significantly.

Sensitive Species. State species of special interest, the golden eagle and greater sandhill crane, would not be significantly impacted by the reservoir. An active golden eagle nest (April 1986) located about 3 miles from the proposed reservoir site on a bluff just north of the town of Kremmling would not be impacted by the reservoir project. The reservoir would impact an insignificant portion of the small mammal prey base for the golden eagle. Loss of the wet meadow habitat would decrease the available habitat for sandhill cranes in the study area, but they are an infrequent visitor to the area.

The development of the proposed reservoir would produce a favorable impact on the federally endangered bald eagle. The development of open water areas on Muddy Creek and the downstream flow below the dam would attract bald eagles wintering along the Colorado River. The decrease in the small mammal base utilized by bald eagles would be compensated for by the increased fish foraging opportunity. The loss of small mammal and avian habitat would decrease a potential food base for peregrine falcons, but would not be considered significant because peregrines are considered a rare visitor to the area.

4.4.8.2 Mitigation. Significant adverse impacts to wildlife are limited to the loss of wetland habitat types and their associated wildlife values, and the loss of big game winter range with the interacting affects habitat loss and reservoir emplacement would have on local elk and mule deer populations.

The significant impact associated with the loss of wildlife values for wetland habitats was quantified in terms of Habitat Units in the same way as discussed for Rock Creek (Section 4.3.8.2). Mitigation of this significant impact would be accomplished by acquiring private lands in the immediate vicinity of the project area that have the appropriate habitat potential to replace wildlife values lost due to construction of the Muddy Creek Reservoir. Additionally, public lands, (BLM and state lands) within the area of concern would be more intensely managed to increase their wildlife values. A management plan would be designed to develop the habitat potential of these lands and retrieve the wildlife values sacrificed due to construction and operation of the reservoir. All of the wildlife values and acreages associated with the loss of important wetlands could apparently be replaced by implementing a mitigation plan as discussed in Section 5.2.5.

Impacts to big game are certainly significant but defy quantification in terms of Habitat Units. Therefore the mitigation proposed to compensate for the impacts to big game is a combination of actions developed by a group of experienced professional biologists familiar with the area and big game. The proposed mitigation plan calls for the following actions:

- Enhancement of wetland and riparian habitats on the bottomlands of Muddy Creek immediately below the proposed dam that would provide some forage and cover for big game.

- Range improvements on private land near the Muddy Creek bottomlands that would increase big game carrying capacity.

- Range improvements on about 800 acres of land within the Muddy Creek big game winter range that would increase carrying capacity for big game.

- Implementing a strategic plan to attract big game to areas newly improved for the benefit of big game.

- Placement of signs on Highway 40 in order to protect big game and motorists from colliding.

- North, south, and on top of Wolford Mountain an additional 800 acres of winter range would be improved using fertilizer and herbicide techniques.

- Haystacks to the north of the reservoir would be protected by fencing.

All of the anticipated impacts to big game were addressed in the proposed mitigation plan (Chapter 5) and thought to be reduced to an acceptable level. In order to determine if big game losses due to movement over the iced reservoir or on Highway 40 significantly affects the wintering big game populations or if snowmobile disturbance is significant, a monitoring program will be conducted during the first three winters following inundation of the reservoir. If losses are deemed to be significant, appropriate actions will be taken to reduce those losses. More details for the proposed mitigation plan for Muddy Creek is found in Chapter 5.

4.4.8.3 Unavoidable Adverse Impacts. The loss of the wildlife values associated with the loss of important wetland habitats can be essentially mitigated by implementation of the proposed plan presented in Chapter 5. Mitigation measures would reduce the significance of these impacts to acceptable losses.

4.4.9. Land Use Plans

4.4.9.1. Anticipated Impacts. The proposed reservoir would inundate 292 acres of public land and 908 acres of private land. This action would essentially eliminate all current land use activities on these areas.

Recreation in the area would increase as the reservoir would provide boating, wind-surfing, fishing, and water skiing opportunities, and camping facilities would introduce additional recreation activities. If the camping facilities were located on private land, rezoning would not be necessary as such facilities are allowed under the Forestry and Open classification following the issuance of a special use permit. Secondary development involving commercial operations would require rezoning. Developed recreation sites on BLM land would be allowed as long as they did not conflict with range or livestock management, in accordance with the Kremmling Resource Management Plan (USDI/BLM, 1984). Intensive and extensive recreation developments would be required to accommodate the recreation use created by the reservoir. The River District as right-of-way applicant would be responsible for managing this use.

4.4.9.2. Mitigation. The three private landowners would have to be compensated for the economic loss produced by inundation of lands by the reservoir.

4.4.9.3. Unavoidable Adverse Impacts. The inundation of 1200 acres of land would constitute an unavoidable adverse impact as existing land uses would essentially be eliminated.

4.4.10. Grazing

4.4.10.1. Anticipated Impacts. Criteria for defining impacts to grazing on the Muddy Creek study area were identical to those used for the Rock Creek study (Section 4.3.10). Impacts to the six affected livestock allotments are summarized in Table 4.4.10.1. Approximately 908 acres of private and 292 acres of public (BLM) land would be inundated by the proposed project. Little or no acreage would be inundated for BLM allotments 7532, 7760, 7764 and 7784. No allotments would lose more than eight percent of its total AUMs, therefore no significant impact attributable to inundation is anticipated (Table 4.4.10.1).

A potential impact to grazing for the private lands affected would involve the loss of base property needed to use federal grazing allotments and the AUMs for the approximately 681 acres of private land inundated. The ranches involved have sufficient base holdings in other areas, and federal permits could be altered to reflect these other holdings. Most of the private land that would be inundated would be wet meadows. Because this land has higher forage production than adjacent sagebrush associations, the loss of quality grazing would be relatively high. An estimated 2043 AUMs would be lost on private land (681 acre x 5 months of grazing x 0.6 units per acre). This loss of AUMs would be significant to the individuals incurring the losses.

4.4.10.2. Mitigation. Because the private lands to be inundated would need to be purchased, the purchase price would include the forage loss. The loss of AUMs on BLM allotments were not determined to be significant and would not require mitigation.

Table 4.4.10.1
Summary of Potential Impacts to Six Grazing Allotments
near the Proposed Muddy Creek Reservoir Site near Kremmling, Colorado

Allotment Number/	Present		Direct Loss		Indirect Loss		Total Loss		% of
Type	Acres	AUMs	Acres	AUMs	Acres	AUMs	Acres	AUMs	Total
7506/C	7722	362	99	4.6	0	0	99	4.6	1.3
7540/C	1264	211	9	2.0	0	0	9	2.0	0.9
7550/C	1370	141	117	9.7	8	1	117	10.7	7.6
7568/C	6741	1600	138	32.8	5	1.2	143	34.0	2.1
7754/C	2268	414	7	1.3	6	1.2	13	2.5	0.6
7765/C	1075	118	44	4.8	12	1.2	56	6.0	5.1
TOTALS	20440	2846	414	55.2	31	4.6	437	59.8	2.1

C = Cattle allotment, AUM = Animal Unit Month

4.4.10.3 Unavoidable Adverse Impacts. None.

4.4.11. Visual Resources

4.4.11.1. Anticipated Impacts. Construction of the Muddy Creek dam and related facilities would cause several potentially significant short and long-term visual impacts. The visual impact of the 1,895 foot dam face and related permanent structures would be substantial and long term. All aspects of the dam proper exceed BLM Visual Resource Management (VRM) Class 2 standards established for the area which state that "changes in any basic element . . . should not be evident in the characteristic landscape".

The primary access road would follow an existing gravel road for 0.5 miles, then descend a moderate slope for a distance of 0.35 miles to the dam. Although this final road section would create visual contrast in line and color, it would not be readily apparent to the majority of viewers and would be in compliance with Class 2 standards. However, the secondary access road would create significant visual impacts. This road would follow an existing gravel road for 3.0 miles, with an additional 0.6 miles of new road required. The new road section would traverse very steep terrain and would require significant cutting and filling, resulting in exposure of large areas of red-brown and buff-brown subsoil. This would be be visible

to motorists on Highway 40, and would create visual contrasts in excess of BLM VRM standards for a Class 3 zone which state that "contrasts . . . should remain subordinate to the characteristic landscape".

Temporary visual impacts of construction activities would include construction of upstream and downstream coffer dams, stream diversion, borrow excavation, construction of the dam embankment, spillway chute, and emergency spillway. Although these activities would result in substantial ground surface disturbance exceeding BLM VRM Class 2 standards established for the area, most would occur below elevation 7,500 and should be screened from the Highway 40 viewshed, and in the long term would be covered by the reservoir impoundment. Consequently, visual impacts of most construction-related activities would be minimal. One exception would involve borrow sites below the dam which would be highly visible to recreationists attracted by the downstream coldwater fishery. Negative impacts could also result from an as yet unidentified quarry site for riprap, which might be in visually sensitive areas not innundated by the reservoir.

Transmission line relocation would not create a visual contrast significantly different from current conditions. The vertical relocation of Highway 40 would create an unnatural land-water interface which would exceed BLM VRM standards for a Class 2 zone, but would also be similar to the present situation. Recreation facilities which might be developed on private property along the western shoreline of the reservoir may have significant visual impacts on either reservoir recreationists or motorists on Highway 40, depending on their location. However, specific impacts cannot be determined until more specific information concerning location, size, and site design of recreation facilities is available.

Water impoundment would inundate 1,200 acres of sagebrush/grassland and irrigated pasture, meandered creek, riparian vegetation and oxbow wetlands. The significant changes in form, line, color, texture, size and patterns resulting from water impoundment would exceed BLM VRM standards for Class 2 and Class 3 zones. Further degradation of the visual resource may result from beaching and exposure of buff brown soils on shoreline sections. Although normal reservoir drawdown would not be extreme (5-15 feet with East Slope sales, and 7-8 feet with West Slope sales), this would intensify the visual impact of shoreline contrast and produce highly visible mudflats which would contrast sharply with the characteristic landscape, particularly along Pass Creek and Deer Creek adjacent to Highway 40. High turbidity levels would also reduce the visual quality of the water resource. However, it should be noted that although the impoundment would be foreign to the characteristic landscape, the reservoir would be a powerful and attractive landscape element which in the long term could increase scenic quality in accordance with BLM VRM criteria.

The exception to this situation would occur during extreme dry periods (1977) when the reservoir would be essentially dry. During this time the exposed reservoir bed would create a significant exceedence of the VRM criteria.

Alternative Dam Site. The visual impacts of a dam constructed at an alternative site would be essentially the same as those associated with the preferred site. The major difference would be the elimination of approximately 0.25 miles of meandering stream below the dam. Although this section of stream is of moderate to high visual quality, it is in a section of Muddy Creek that is seldom seen.

Impact Summary. Visual impacts resulting from the dam and reservoir would exceed present BLM VRM guidelines, requiring a change in the Resource Management Plan (RMP). Significant impacts would be caused by the downstream material site, secondary access road along the western toe of Wolford Mountain, and by the reservoir during periods of substantial drawdown, such as 1977.

4.4.11.2. Mitigation. The VRM classification for the reservoir area would need to be changed in the RMP to accommodate the reservoir. Grading, sloping, and contouring the material site to fit the natural contours, and revegetation of the site would mitigate most of the visual concern. Similar mitigation for the access road cut would reduce, but probably not eliminate, the visual concern. Although the road would still be visible, the impact could be reduced to a level considered not significant.

4.4.11.3. Unavoidable Adverse Impacts. VRM would be exceeded by the reservoir during an extreme dry period.

4.4.12. Recreational Resources

4.4.12.1. Anticipated Impacts. Development of a reservoir at the Muddy Creek site would generate several relatively minor adverse impacts on existing on-site recreation resources and use patterns. The reservoir would inundate a part of the stream bed and wetland area that currently provides limited waterfowl hunting opportunities. Although use levels of this area are relatively low and not all of the area would be covered by the reservoir, some negative impacts would be experienced by hunters because there are very few alternative waterfowl hunting areas in the vicinity.

Some minor impacts on big game hunting opportunities would also result, due both to loss of the area covered by the reservoir itself and limited population reductions of deer and elk herds. As noted in section 3.13.2, however, the area directly affected by the reservoir itself receives only limited hunting use. In addition, as noted in Section 4.4.8, effects on deer and elk herds would generally be considered significant but mitigation would alleviate the impacts. Consequently, any adverse impacts on big game hunting and associated seasonal business activities and economic opportunities for residents of the Kremmling area would be of very limited significance.

Other onsite recreation activities that would be disrupted by reservoir development are quite limited, involving primarily some off-road vehicle, motorcycle, and target shooting uses. Because there are numerous other locations in the area that provide opportunities for these kinds of recreation, the impact of their displacement by reservoir development would be not be considered significant.

Flow changes in the sections of the Colorado River used by floatboaters would be limited and would have no significant effects on this form of recreation use, especially since the simulated baseline flows would be inadequate to support existing recreation use. Flow changes during summer floating months would generally be less than 20 cfs (Appendix A) and therefore, would not impact present flows and associated floating significantly.

As noted in Section 4.3.3.4, flows in the Blue River below Dillon Reservoir would be reduced, but the magnitude and frequency of the reduction cannot be quantified. A reduction in flows would reduce the amount of time the river would be acceptable for floatboating. Therefore an adverse impact to floatboating could occur, although it cannot be quantified. A similar impact was noted in the Metropolitan Denver Water Supply EIS (U.S. Army Corps of Engineers, 1986), and it was considered significant. Since releases from Dillon related to Muddy Creek would be much less in frequency and magnitude than the Denver releases, the Muddy Creek impacts would not be significant, but it may add cumlatively to the significant impact of Denver.

Several positive consequences of reservoir development would be anticipated. Development of the reservoir would result in potential water quality improvements on the section of Muddy Creek between the dam and the Colorado River, providing for the development of a potential new trout fishing opportunity along that stream section (see Section 4.4.7). The Muddy Creek Reservoir itself would provide for a moderate quality lake fishery, and would also create a new recreation resource for boating, sailing, water skiing, windsurfing, and other lake-related recreation activities. Given recent growth of windsurfing use on nearby and similarly situated Green Mountain Reservoir, it is particularly likely that the Muddy Creek Reservoir would attract substantial numbers of windsurfers.

The Bureau of Land Management would not develop campgrounds or other facilities at the reservoir because most of the land between U.S. Highway 40 and the reservoir basin is privately owned. However, Grand County is proceeding with a recreation planning analysis that would include planning for campgrounds, boat ramps, and other facilities for a reservoir on Muddy Creek, and it can be assumed that such facilities would be developed by the county and/or private developers to meet recreation-related demands created by the reservoir.

A recreation demand study prepared in 1985 provides a basis for anticipating substantial recreation use at the Muddy Creek Reservoir. That analysis projects that by the year 1990, the reservoir would attract about 145,000 recreation visitor days (RVDs), with visitation increasing to over 185,000 RVDs by 2010. Because the demand analysis could not model the effects of private recreational development on visitation, it is likely

that these estimates somewhat under-represent the actual levels of recreation use that would occur. Given that visitation at nearby Green Mountain Reservoir exceeds 200,000 RVDs annually, it is likely that in the near term recreation visitation to the Muddy Creek Reservoir would be closer to 150,000 to 175,000 RVDs per year. Visitation would drop dramatically during extreme dry periods (1977) when the reservoir would be essentially dry for one year. Visitation would build back up fairly quickly since the reservoir would be filled in the following year.

Even though a substantial portion of this visitation would likely involve a reallocation of existing visitation from other area reservoirs such as Green Mountain Reservoir and Williams Fork, some additional visitation would also be generated, due in part to the location of the Muddy Creek site adjacent to a major U.S. highway. Although visitation would be less than that which presently occurs at existing developed reservoir recreation sites such as Green Mountain Reservoir (about 200,000 RVDs in 1983) and Steamboat Lake (about 250,000 RVDs in 1983), it would nevertheless likely provide a stimulus both to recreation development on private lands adjacent to the reservoir and recreation and tourism services expansion in Kremmling. Such development would help to stimulate additional summer season tourism to Grand County, providing a counterbalancing effect to the present winter tourism concentration.

To summarize, the Muddy Creek Reservoir would have minor adverse impacts on waterfowl hunting, and minor adverse impacts on big game hunting. Altered flows on the Colorado River would not significantly disrupt recreation uses involving river floating from the assumed baseline conditions. Postive impacts would include the potential creation of a trout fishing recreational opportunity on the lower section of Muddy Creek, and fishing, boating, sailing, and other lake recreation activities on or adjacent to the reservoir.

4.4.12.2. Mitigation. Although potential negative impacts on both waterfowl hunting and big game hunting would be of limited significance, mitigation proposed for wetlands and wildlife (Chapter 5) should replace the lost hunting opportunities.

4.4.12.3. Unavoidable Adverse Impacts. No significant unavoidable adverse impacts on recreation resources or opportunities would be anticipated. Loss of some floatboating below Dillon Reservoir on the Blue River would be unavoidable.

4.4.13. Cultural Resources

4.4.13.1. Anticipated Impacts. Prehistoric and historic properties could be affected as a result of construction activities related to dam construction, realignment of existing features such as Highway 40 or the transmission line and inundation. Potential future adverse impacts to

resources could also result from visitor or recreational use of the reservoir. At present, the total number of cultural resources and their significance is unknown because intensive cultural resource identification and evaluation studies have not been conducted. Based solely on known information, it is possible to delineate some potential impacts.

Of the 11 recorded cultural resource sites, none have been completely evaluated for National Register of Historic Places (NRHP) eligibility. Identifiable potential impacts at this time include one prehistoric lithic scatter located near the proposed secondary access road to the dam site, and three prehistoric sites and one recorded homestead that would be inundated by the reservoir. In addition, the unrecorded Short Ranch would also be flooded. Based on the lack of intensive cultural resource inventory in the project area, it is probable that additional cultural resource impacts would be identified once the number and distribution of such resources is more fully known.

Therefore, due to potential impacts to important known, as well as unknown, cultural resources, impacts to cultural resources would be considered significant.

4.4.13.2. Mitigation. In order to fully address the potential impacts to cultural resources at the Muddy Creek site, further intensive cultural resources inventory would be required for both the reservoir and adjacent areas. This work would also have to address NRHP evaluations for previously recorded resources. Any significant sites located within the area may require data recovery, dependent on the type and severity of impact.

4.4.13.3. Unavoidable Adverse Impacts. The mitigation proposed above should reduce impacts to cultural resources to an acceptable level.

4.4.14. Paleontology

4.4.14.1. Anticipated Impacts. Paleontological resources of the Muddy Creek affected area are generally common forms that are abundant in other areas. Therefore, no significant impacts to paleontological resources would occur.

4.4.15. Social Environment

4.4.15.1. Anticipated Impacts. As indicated in Section 2.3.4.4, construction of the Muddy Creek dam and reservoir would require approximately 120 workers at the construction peak. An estimated 48 of these would be non-local workers who would have to temporarily relocate to the Kremmling area. It is reasonable to assume that very few of these relocating workers would be accompanied by family members, given the two-year

seasonal project construction schedule. Consequently, temporary population growth effects on Kremmling and other nearby areas of Grand County would be minimal, and would be readily absorbed by the existing public and private service infrastructures of the Kremmling area. No significant effects on area school enrollments would be anticipated due to the limited in-migration of families with children and the seasonal construction schedule. The limited scale and short-term, seasonal character of this population influx would also be unlikely to generate any noticeable effects on community social conditions or local ways of life.

Reservoir development at this site would innundate parts of five ranches, involving both grazing and important calving areas, as well as a number of older houses, barns and sheds. None of the affected ranch parcels are currently being used as ranch headquarters or as permanent year-round residences. However, two of the affected parcels are used to provide seasonal housing to ranch employees. In addition, these parcels are "base" properties to which leased grazing rights on BLM and National Forest System lands are linked. Consequently, inundation of these ranch tracts would not only involve a loss of the affected land area, but could also make it difficult for ranch operators to maintain some grazing leases.

Although it appears that these effects would not jeopardize the ability of the affected ranches to continue their larger overall operations, the elimination of ranching activities at the affected locations would contribute further to a gradual and ongoing disappearance of the traditional ranching-based social and cultural features which have characterized western Grand County. This effect would be compounded by the development of recreation and tourism-based activities that may be prompted by the reservoir. As with the siting of a reservoir at Rock Creek, effects that might hasten the disappearance of traditional rural lifestyles and values would be welcomed by some residents, while for others such changes would contribute to heightened dissatisfaction.

In general, during scoping there was widespread support for the Muddy Creek Reservoir among both local residents and public officials. Since that time Grand County officials have indicated support for the Rock Creek site over the Muddy Creek site (see Section 2.4 for details). Some Kremmling residents may be expected to experience dissatisfaction related to perceived risks of dam failure; at present there is no indication that the project would generate widespread dissatisfaction or community conflict among project opponents and proponents.

Overall, the development of a dam and reservoir at Muddy Creek would not result in a large influx of project employees or any significant growth-related disruptions to the local community. Inundation of several ranch parcels and the longer-term prospect for recreation related growth would contribute to a more rapid disappearance of the traditional social and cultural characteristics of eastern Grand County. No other significant social impacts would be anticipated.

4.4.15.2. Mitigation. Impacts on affected ranching operations could be mitigated by monetary compensation, which at the choice of individual ranchers could presumably be used to acquire replacement lands.

4.4.15.3. Unavoidable Adverse Impacts. Possible long-term effects involving a more rapid disappearance of traditional rural, social, and cultural conditions would not be prevented by mitigation, and would therefore be unavoidable consequences of the project.

4.4.16. Economics

4.4.16.1. Anticipated Impacts. A cost/benefit analysis was conducted for the Muddy Creek Reservoir and is explained in detail in Appendix B. Due to the lease with Denver, the cost/benefit value was 2.5 for the reservoir, indicating a very viable project economically. The sale of Muddy Creek reservoir releases is to serve the same purpose as Rock Creek, and would not have economic impacts which result from production associated with water availability in the two-county region. Thus, as in the case of Rock Creek reservoir, no regional impacts are expected from water sales. The major impacts on the economy of the region will, again, come from construction activity, recreation use, and livestock operations.

Construction of the Muddy Creek dam, the associated modification of Highway 40 and the relocation of transmission lines would also require two years. Hired labor would consist of 487 man-months in the first year, and 485 man-months in the second year. Wages paid would amount to approximately \$1.1 million per year, and, again, it is anticipated that 60 per cent of the labor would be hired locally. The resulting local expenditure (assuming half of the wages from imported labor would be spent in the counties) would be about \$900,000; the multiplier effect of 1.8 would result in a total increase in household income of slightly under \$1.6 million per year for the two counties. In addition, equipment and materials would be leased or purchased locally.

Since the Muddy Creek dam would not require specialized equipment and material for construction, a larger portion of expenditures and construction could be expected to occur in the two-county region than for the Rock Creek site. Approximately \$1 million per year of local purchase or lease (excluding labor) might be expected (concrete and filter material will be furnished locally, but riprap materials may have to be purchased from out of the two-county area). Using the construction multiplier of 1.8 for the two-county region, the resulting increase in sales activity would be approximately \$1.8 million for each of the two years, which would result in an additional \$630,000 in local income and an additional 25 to 30 local jobs.

Furthermore, land acquisition would be required on this site, since most of the inundated area is held privately. The reservoir would cover approximately 1,200 acres when filled. Purchase of private land, at an average price of \$1000 per acre (grass, hay and pasture land), would result in a local payment of approximately \$1,600,000. It is not known how much of this payment would be spent locally. As in the case of the Rock Creek dam construction, these changes in employment and income may be very significant to specific localities and individuals, but comprise less than 5 per cent of the total economic activity in the two-county region.

Livestock operators would be affected to some degree by the reservoir. There are four ranches involved in the area to be inundated, with two of those ranches having significant parts of hay production and calving grounds involved. Further, one of the ranches has possible historical sites on it, consisting of farm buildings dating from the homesteading era. Each operator was contacted personally, and none indicated that the inundation of the property would result in serious economic consequences to their operations. Given that private ground will have to be purchased, compensation for those losses would be made.

Recreation visitation to Muddy Creek is projected in Table 4.3.16.1 and was discussed in the Recreation section. The visitation is somewhat lower than for Rock Creek, primarily because of the lower attractiveness and smaller minimum pool surface acres of the site. It is estimated that from 150,000 to 175,000 visitor days would occur in 1990. Using 175,000 visitor days and $25 local expenditures per visitor-day results in an estimated increase of total sales of approximately $4.38 million, of which approximately $1,300,000 to $1,500,000 would be captured in local income. This also would result in approximately 52 additional jobs created in the two-county region. In addition, reduction in visitation during extreme dry periods would reduce the income stream for a year, perhaps to near present levels.

As in the case of Rock Creek Reservoir, these projection of income and employment data appear to be high, primarily because of the reallocation of trips among users of similar recreation sites in the two-county region. There are no significant losses in economic activity resulting from existing recreation on the Muddy Creek site. It would appear that the large majority of these economic benefits to the construction of Muddy Creek reservoir would accrue in Grand County, although a precise estimation of this proportion is impossible. As in the case of Rock Creek reservoir, the changes in income, employment, and sales resulting from the proposed construction would be significant to specific individuals and communities, but would be less than 5 per cent of existing conditions in the two-county region.

There appear to be no significant changes in the numbers or activity of local big game or small game populations. Therefore it is doubtful that the effect of the reservoir would be significant to hunting in the two-county region, although stocking of gamefish in the reservoir would cost $10,000 per year.

There would be no significant impact on the river floating industry in the affected reaches of the Colorado River, given that existing rights would reduce flows below the minimums necessary to support floating without the existence of Muddy Creek Reservoir.

4.4.16.2. Mitigation. As indicated above, payment for private ground to be inundated would mitigate economic losses to local ranchers. Other than these losses, there appear to be no adverse economic impacts associated with the construction of Muddy Creek Reservoir.

4.4.16.3. Unavoidable Adverse Impacts. There appear to be no significant unavoidable adverse economic impacts associated with the construction of Muddy Creek Reservoir.

4.4.17. Transportation

4.4.17.1. Anticipated Impacts. Muddy Creek Reservoir would inundate about 800 feet of U. S. Highway 40. At the present crossing of Red Dirt Creek (see Fig. 2.6), the existing roadway has a low elevation of about 6 feet below normal maximum reservoir water surface. While the horizontal alignment is suitable, the minimum road grade would need to be raised to just above maximum reservoir level during the passing of the design flood (elevation 7489). The culverts under the road would be extended and the slopes of the road fill within the reservoir would be protected with riprap. The total length of modification would be about ½ mile. During construction of the road section, there would be short-term impacts on vehicular traffic on Highway 40 (which is moderately to heavily traveled by recreationists going to the Steamboat Springs area and trucks hauling logs to the Louisiana Pacific facility in Kremmling). Traffic could be reduced to one-way or a detour provided.

Much of the material required for construction of Muddy Creek dam would be obtained from a borrow area in the reservoir basin above the dam (about ½ mile haul). Some material may be acquired from just below the dam. Depending on suitability of local materials, filter materials (about 78,000 cu yd) may need to be obtained from a supplier in Kremmling. About 17,800 cu yd of riprap materials for the dam face will have to be obtained from a quarry source as much as a 40-mile haul distance east of the site. Hauling these materials would increase truck traffic on Highway 40 during portions of two construction seasons (April-October). If materials are hauled in 20-ton capacity trucks, about 6,000 local hauls and about 1,400 long distance hauls would be required. Again, there would be a short-term increase in traffic-related problems.

4.4.17.2. Mitigation. Increased traffic problems related to materials hauling would be mitigated by accepted traffic control measures, including: warning signs, truck speed limits, and flag persons where necessary. During construction of the Highway 40 road section, one-way or detour traffic controls would be instituted.

4.4.17.3. Unavoidable Adverse Impacts. There would be unavoidable short-term increases in truck traffic during portions of two construction seasons, and short-term traffic delays on Highway 40 during road construction.

4.5. Cumulative Impacts

4.5.1. Introduction.

4.5.1. Introduction. This section describes the cumulative impacts that would be expected if either the Rock Creek or Muddy Creek alternative were selected. A cumulative impact is an incremental impact caused by the proposed project that would add to the impacts of past, present, or reasonably foreseeable future projects, or would add to the normal changes or trends taking place in the present day environment.

4.5.2. Affected Environments. The affected environments for the Rock Creek/Muddy Creek project include the Routt/Grand county area since this is where the projects would be built, the upper Colorado River system since that is the system that would be affected by water storage and exchange, and the general area of the Metropolitan Denver Water Supply EIS (U. S. Army Corps of Engineers, 1986) since Denver would lease the water from the project. Therefore cumulative impacts could include much of the state of Colorado.

4.5.3. Review of Project Impacts. The analysis in the preceding portions of Chapter 4 indicates that the Rock Creek alternative would cause significant adverse impacts to wetlands, stream fish habitat, big game habitat (elk and deer), visual resources, and stream recreation, and could cause social conflict between different user groups. Mitigation would alleviate most of the impacts to wetlands and some of the impacts to fish and wildlife habitat. The Muddy Creek alternative would also impact wetlands, a candidate federal rare plant, big game habitat (elk and deer), and visual resources. Mitigation would alleviate the wetland and wildlife impacts, and most of the rare plant and visual impacts. Therefore, the potential cumulative impacts of the project involve those impacts that would not be mitigated or the unavoidable adverse impacts. Beneficial impacts of both alternatives include increased recreational use of the reservoirs and associated campgrounds, reservoir fish habitat and the economic benefits of the recreational use. Muddy Creek would also create a potential benefit in a cold water trout fishery in the tailwater of the dam.

4.5.4. Potential Sources of Cumulative Effects

4.5.4.1. General. As indicated in the Introduction to this section, cumulative impacts can occur from four sources--past projects, present (concurrent) projects, future projects, or present trends in the affected environment. Past projects that have been built in the area include Green Mountain, Dillon, and Williams Fork reservoirs, Bear River reservoirs in the upper Yampa drainage, the Steamboat Springs Ski Area, and Lake Catamount. Concurrent projects include the Stagecoach Reservoir Project on the Yampa River and the Metropolitan Denver Water Supply Study. Future projects would include the Catamount Ski Area and Fish Creek Ski Area in Routt County and a larger Muddy Creek Reservoir in Grand County. Present trends that may be important include the expanded airport in Routt County, the

depressed economy in western Grand County, and the general trend in the area away from traditional ranching/mining/logging economies to recreation and tourism oriented economies.

4.5.4.2. Past Projects. The existing reservoirs, Green Mountain and Dillon on the Blue River and Catamount and the Bear River reservoirs on the Yampa River, have probably all adversely impacted wetlands, stream fishery habitat, and rare fish habitat downstream in the Colorado River. The major beneficial impact has been increased reservoir recreational opportunities. Stream fishery habitat quality was probably improved below Dillon and Green Mountain reservoirs due to more stable flow regimes. Some of these reservoirs may also have adversely impacted big game habitat. Many of these impacts may have been mitigated much as proposed for the Rock Creek/Muddy Creek proposals, others were built before environmental concerns were institutionalized and mitigation was probably not instituted.

The impacts from the Rock Creek alternative would add incrementally to the loss of stream fisheries due to past reservoir development, and the loss of big game habitat capability, especially on National Forest System lands. Both reservoirs would add slightly to the cumulative wetland and rare fish habitat losses, as well as increased reservoir recreation. The loss of the stream habitat at Rock Creek would add to the already significant loss of quality stream fish habitat that has occurred throughout Colorado. The increase in cold water habitat in the tailwater of Muddy Creek Reservoir would be a cumulative beneficial impact by increasing the total amount of habitat available. The cumulative effect of Rock Creek or Muddy Creek flow alterations would also add slightly to the already significant impact to the rare fish downstream in the Colorado River.

4.5.4.3. Concurrent Projects. The Stagecoach Reservoir Project (USDI/BR, 1986) and the Metropolitan Denver Water Supply Project (U.S. Army Corps of Engineers, 1986) could both potentially occur at the same time as the Rock Creek/Muddy Creek project. The Metro Denver project could involve a variety of water supply alternative and options, one of which is the Rock Creek/Muddy Creek proposal. Potential additive cumulative impacts could involve wetlands, stream fish habitat, rare fish habitat, big game habitat, visuals, and social conflict. Since the Rock Creek/Muddy Creek project is a site-specific alternative in the Metro Denver study, cumulative impacts noted in the DEIS for that project (U.S. Army Corps of Engineers, 1986) are incorporated here by reference.

A major impact of Metro Denver project(s) is flow changes in the Colorado and Blue rivers. These flow changes would cause significant impacts to the river floatboating industry, as well as private floatboaters, in both river (U.S. Army Corps of Engineers, 1986). The Rock Creek/Muddy Creek proposals would reduce flows in the Blue and Colorado rivers only slightly and would not be significant by themselves. But the incremental reduction in flows would add to the significant impact of Metro Denver, creating a slightly more significant impact.

The Stagecoach Project would adversely impact wetlands, stream fish habitat, rare fish habitat, and big game habitat, but most of the impacts would be mitigated. The reservoir would attract about 71,000 recreational visitor days for the first 5 years. The Rock Creek site would attract up to 175,000 RVDs. There would probably be some interchange between the two that would decrease the visitation at both sites, but overall a significant increase in visitor days would be expected. As noted in earlier portions of this chapter, the visitation at Rock Creek would probably take considerable visitation away from other existing reservoirs such as Steamboat Lake. Two new reservoirs at Stagecoach and Rock Creek could potentially reduce use of present sites substantially. Therefore, the pattern of recreational use of reservoirs in Routt County could change significantly, and an overall increase in recreational use would occur. Such a change would create additional losses in traditional lifestyles and increase the change to a recreation oriented economy in the county.

Interchange between Muddy Creek and Stagecoach reservoirs would probably not occur in the same proportion as Rock Creek/Stagecoach. Since Muddy Creek is some distance, and over a pass, from the Steamboat area, it should not compete with Stagecoach Reservoir for visitors at the same level as Rock Creek would compete. Loss of visitation from Steamboat Lake would also not be as severe with Muddy Creek as with Rock Creek. Muddy Creek would probably take visitation away from Williams Fork and Green Mountain reservoirs.

4.5.4.4. Future Projects. Future projects in Routt County include the proposed Catamount and Fish Creek ski areas. These projects would increase both winter and summer recreational visitation and increase the urbanization of the Steamboat Springs area. Rock Creek Reservoir could add incrementally to these increases by providing additional recreational opportunities, especially during summer. This would be a beneficial impact from the standpoint of recreational visitation and economics but may create additional social conflict as lifestyles of the area change. These projects may also impact wetlands, stream fisheries and big game habitat and add to the impacts of the Rock Creek project. It is doubtful that any of the impacts would be significant from a cumulative standpoint following mitigation.

A larger reservoir on Muddy Creek could be constructed in the future if Rock Creek was selected and constructed at this time. Such a reservoir would have adverse impacts to wetlands, rare plants, and big game habitat and many of these impacts may be very difficult to mitigate. This would add to the big game impacts of Rock Creek. This reservoir would also add to the cumulative flow alterations that have affected rare fish habitat in the downstream portions of the Colorado River. It is expected that the cumulative impacts of a larger Muddy Creek Reservoir could be significant by themselves for most of the impacts noted above and that the Rock Creek incremental additions would be minor except perhaps for the rare fish.

Additional reservoir sites in this region of the Upper Colorado River drainage are also under consideration (see Sections 1.5.3 and 2.2). It is likely that such sites as Red Mountain, Azure, and Wolcott would involve

similar impacts as those expected from a large Muddy Creek Reservoir on wetlands, big game habitat, and stream fishery habitat, as well as cumulative effects on rare Colorado River fish.

4.5.4.5. Present Trends. The Rock Creek alternative would increase the present trends of increased recreation in Routt County. The increase would be an overall increase since areas such as Steamboat Lake would actually be adversely impacted by Rock Creek as visitation would decline.

Both the Rock Creek and Muddy Creek alternatives would increase the recreational visitation to western Grand County, improving the economy that is presently heavily reliant on ranching and logging. The Muddy Creek alternative would have the greatest benefit since it is wholly in Grand County. This may help the current economic trend and add to the trend of increased recreation in the local economy. This could be a significant beneficial impact to western Grand County.

4.5.5. Rare Fish. The rare fish in the downstream sections of the Colorado River have been impacted by past flow alterations due to water development projects. They would also be impacted by concurrent and future projects, as well as present trends. These cumulative impacts are addressed in more detail in a Biological Assessment. The Fish and Wildlife Service has recently been assessing conservation measures to mitigate cumulative impacts. Such measures have resulted in a non-jeopardy opinion being issued by the Fish and Wildlife Service on cumulative impacts. The following cumulative analysis addresses the cumulative effect of past and present projects on the rare fish in more detail.

4.5.5.1. Colorado Squawfish. As noted in the Rock Creek alternative discussion, flow depletion has been indicated as a major factor in the decline of Colorado squawfish. A potential significant impact of this project on Colorado squawfish is the cumulative effect of the Rock Creek/Muddy Creek water depletion with that of numerous oil shale and other developments in the upper Colorado River Basin. The Bureau of Reclamation has recently completed the Dolores and Dallas Creek projects and is in the process of marketing additional water from Green Mountain and Ruedi reservoirs. Non-Federal developments include Ridges subdivision, Homestake II, Battlement Mesa, Windy Gap, Denver Water Board, and others. Oil Shale projects include Getty, Conoco and Chevron, Cities Service, Pacific, Union, Mobil, and others. Fig. 4.5.1 shows the proposed projects in the upper Colorado River Basin.

Table 4.5.1 shows the potential cumulative depletion due the projects, including Rock Creek, planned for the Colorado River. These depletions were obtained from the Metropolitan Denver Water Supply EIS cumulative depletions analysis. The greatest depletion percentages would occur in June, July, December, and January when 15 percent or more of present flows would be depleted at the Cameo gage. Downstream at the Cisco gage, depletions of 12 to 13 would occur in April, June, and July.

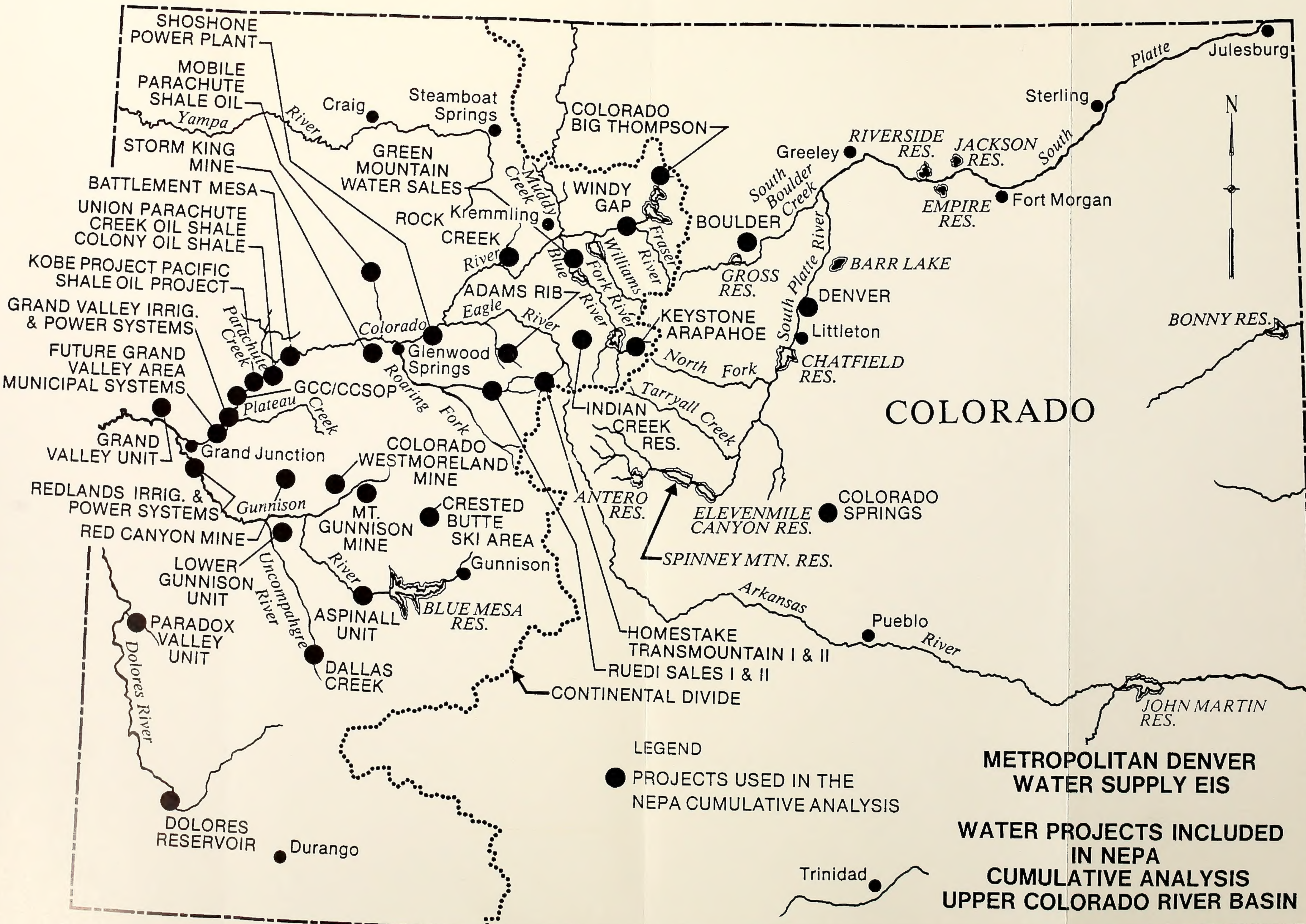


Fig. 4.5.1. Water projects considered for cumulative impacts analysis in Metropolitan Denver Water Supply Systemwide EIS (from U. S. Army Corps of Engineers, 1987).

Table 4.5.1. Present and future flows in the Colorado River at Cameo and Cisco based on project cumulative water development projects.

Colorado River
(Near Cameo)

Month	Baseline Flow	Two Forks Incremental Flow Change		Williams Fork Gravity Incremental Flow Change		Cumulative Flow Change	
	c.f.s.	c.f.s.	percent	c.f.s.	percent	c.f.s.	percent
			28-Year Average				
Jan	1,640	0	0	0	0	-261	-15
Feb	1,575	0	0	0	0	-232	-14
Mar	1,673	0	0	0	0	-215	-12
Apr	2,660	0	0	0	0	-206	-7
May	6,987	-72	-1	-7	0	-137	-2
Jun	11,013	-637	-6	-116	-1	-1,752	-15
Jul	5,327	-292	-6	-24	0	-881	-16
Aug	2,484	0	0	0	0	-180	-7
Sep	2,012	0	0	0	0	-152	-7
Oct	1,990	0	0	0	0	-148	-7
Nov	1,953	0	0	0	0	-225	-11
Dec	1,753	0	0	0	0	-272	-15
Ann Avg	3,422	-83	-2	-12	0	-388	-11

Colorado River
(Near Cisco, Utah)

Month	Baseline Flow	Two Forks Incremental Flow Change		Williams Fork Gravity Incremental Flow Change		Cumulative Flow Change	
	c.f.s.	c.f.s.	percent	c.f.s.	percent	c.f.s.	percent
			28-Year Average				
Jan	4,042	0	0	0	0	-292	-7
Feb	4,057	0	0	0	0	-272	-6
Mar	4,299	0	0	0	0	-360	-8
Apr	6,508	0	0	0	0	-781	-12
May	12,882	-72	-1	-7	0	-938	-7
Jun	16,246	-637	-4	-116	-1	-2,158	-13
Jul	7,304	-292	-4	-24	0	-917	-12
Aug	3,399	0	0	0	0	-178	-5
Sep	3,328	0	0	0	0	-71	-2
Oct	3,963	0	0	0	0	-116	-2
Nov	4,282	0	0	0	0	-229	-5
Dec	4,115	0	0	0	0	-307	-7
Ann Avg	6,202	-83	-1	-12	0	-552	-9

Source: U. S. Army Corps of Engineers, 1986.

The Cisco USGS gage just across the Colorado border in Utah reflects the flow of most areas used by Colorado squawfish since it is located within the area used most heavily by this species. Actual year-to-year variations in depletions would be expected to show even greater percentage depletion in below-average flow years. The level of depletion shown in Table 4.5.1 would be a significant reduction in flow and would be continuing a trend that has caused the present concern for this species. It is not known exactly how lowered flows affect Colorado squawfish, but this cumulative depletion would increase the negative aspects of this phenomenon. Therefore, even though the Rock Creek/Muddy Creek project is relatively small in relation to many other depletions, it still contributes to the cumulative impact and, therefore, may affect Colorado squawfish.

The cumulative depletion of these upper Colorado River projects may also alter temperature and sediment transport mechanisms, especially during flow-flow periods, because rather large portions of the flow may be depleted.

4.5.5.2. Humpback Chub. The cumulative impacts of the Rock Creek/Muddy Creek depletion, plus that of other recent or planned development (Table 4.5.1), would cause significant reductions (10 to 13 percent) in monthly and instantaneous flow in the Black Rocks area, a major population center for humpback chub. Average flows in May and June would be reduced 13 and 12 percent, respectively. These reductions may well alter temperature patterns, or other habitat parameters, and continue favoring more roundtail chubs in that area, causing the increased breakdown of reproductive isolating mechanisms. This could result in more hybridization and perhaps the eventual swamping of the humpback chub population. Therefore, the cumulative effect of the Rock Creek/Muddy Creek project may affect humpback chub.

4.5.5.3. Bonytail Chub. The bonytail chub is nearly extinct in the portions of the Colorado River of concern here and, therefore, the proposed project could have no cumulative effect on this species.

4.5.5.4. Razorback Sucker. The razorback sucker is not a listed species and, therefore, is not covered by the Endangered Species Act. It is a candidate species though and may be listed in the near future.

The cumulative effect of the Rock Creek/Muddy Creek depletion plus other potential depletion as shown in Table 4.5.1 could be a problem for razorbacks. The cumulative depletions that would affect the area above Grand Junction are those of the Cameo gage. The amount of cumulative depletion is rather large and, therefore, may affect razorback sucker reproductive success.

It is difficult to say at this time if the razorback population above Grand Junction is already doomed to extinction because the river has been depleted sufficiently so that reproductive success is no longer achieved.

If this is the case, the Rock Creek/Muddy Creek project would make little additional difference. On the other hand, this population may be reproducing at irregular intervals and therefore maintaining itself. The project, along with other cumulative depletions, could reduce rates of reproductive success to levels that would cause the eventual loss of the population.

Razorback sucker populations below the Government Highline Dam would also be affected by the cumulative depletion of the Green Mountain Water Sales project and other planned water development projects. If, in fact, reduced flows are the major reason for the poor success of remaining populations, these cumulative impacts would exacerbate the present problems.

Therefore, the Rock Creek/Muddy Creek project may affect razorback suckers through the cumulative depletion of Colorado River flows.

4.5.6. Summary. Both alternative reservoir projects would add to the cumulative impacts to the rare fish of the upper Colorado River Basin, to the cumulative loss of wetlands and wildlife habitat, and would add to the trend of a recreation oriented economy and detract from traditional ranching/mining/logging lifestyles. The Rock Creek alternative would add to the cumulative loss of self-sustaining stream fisheries and associated recreation, and to habitat capability of National Forest system lands. Rock Creek would probably impact use at existing reservoirs (Steamboat Lake) and planned reservoirs (Stagecoach) more than Muddy Creek would. Muddy Creek would probably have a more direct cumulative benefit to the economy of western Grand County than Rock Creek would have to either Grand or Routt counties. Rock Creek would compete more directly with existing and planned reservoirs and other recreational developments.

5.0. MITIGATION

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5.0. MITIGATION

5.1. Introduction

This chapter describes mitigation of impacts noted in Chapter 4. It provides more detail on site-specific mitigation plans and addresses ongoing studies that will monitor the effectiveness of mitigation. These studies will be reported in greater detail in the Final EIS (FEIS). Where possible, mitigation measures proposed were designed to mitigate as many impacts as possible. For example, attempts were made to mitigate biological impacts to wetlands, fisheries, and wildlife at the same site. This was consistent with the impacts that would occur due to the various alternatives since one overall impact, inundation by a reservoir, would create the major impacts to wetlands, fisheries, and wildlife that would require mitigation.

The Colorado River Water Conservation District's Ritschard Reservoir Committee met on July 9, 1987, to review the proposed mitigation plan for a reservoir to be constructed either at Rock Creek or Muddy Creek. The Committee recommended and the River District Board confirmed on July 21, 1987, that the Colorado River Water Conservation District accepts the concept of the mitigation plan as outlined in this chapter.

Mitigation that did not require development of a plan or additional funding by the proponent, such as changes to the Forest Plan for land use and visual resources impacts, are not addressed in this chapter.

5.2. Rock Creek Alternative

5.2.1. Surface Water. Changes to surface-water resources for Rock Creek would be changes in streamflow resulting from reservoir operations. Impacts and mitigation would be related primarily to recreation and aquatic biology which are discussed separately below.

5.2.2. Vegetation. Significant impacts to vegetation due to the Rock Creek Alternative involved a loss of vegetation and wildlife values of wetlands. Wetland impacts involved the loss of 250 acres of riparian willow wetland, 214 acres of wet subirrigated meadow, 2 acres of beaver ponds and 20 acres of stream. The wetland impacts were also quantified using the Habitat Evaluation Procedure (HEP), a method of evaluating vegetation attributes (such as cover, diversity, and species composition) based on the needs of various wildlife indicator species. Therefore, the HEP analysis provides a basis to quantify the wildlife value of the wetland vegetation that would be lost at Rock Creek. It also provides a method of determining the existing value of wetlands at a mitigation site and the potential for increasing that value for mitigation purposes.

Mitigation of this impact was developed in cooperation with the Corps of Engineers, CDOW, USFWS, BLM, and the Forest Service. Two strategies were investigated for mitigating wetland impacts: replacement with man-made

wetlands and replacement by upgrading existing wetlands in poor condition. Due to the large number of acres of wetlands at Rock Creek (486 acres), and the scarcity of sites with the necessary conditions for successful establishment of wetlands, upgrading existing wetlands became the major focus. Seven sites were originally considered. Four of those were discarded from consideration for a variety of reasons, mainly a lack of potential for mitigation or insufficient size. Three sites were investigated in more detail--Brinker Creek, King Creek, and Egeria Creek.

Following a preliminary review, which included a field visit, properties along Brinker and King creeks (near Toponas, CO) were determined to be too small to mitigate the impacts noted above by themselves. They also did not provide much in the way of potential mitigation for fisheries impacts because the streams are quite small.

A review of the mitigation potential of land on and adjacent to Egeria Creek, also near Toponas, indicated that most of the impacts to wetlands could likely be mitigated using this area. Also, this area offered the best potential for mitigation of wildlife and fishery impacts of the three sites.

Presently the Egeria Creek area is mainly ranchland and is used for pasturing cattle and horses during snow-free months, as feeding areas during the winter for cattle and horses, and for raising hay. Much of the bottom lands are flood irrigated and are covered with various grasses and forbs typical of wet soils. Very few willows, trees or other woody species are found along the creek banks. The upland portions are covered with grasses, forbs, sagebrush, other shrubs, and rocky areas. Most of the site is between 8140 and 8300 feet in elevation.

The amount of area needed would involve the purchase of approximately 2100 total acres of which 568 acres would be directly usable for mitigating impacts involving the loss of wetlands and associated wildlife values while about 1500 acres would be useful for mitigating impacts to general non-forested wildlife habitat. Several landowners could be involved in the acquisition of the required acreage.

The Egeria Creek site provides the opportunity to utilize an existing wet subirrigated meadow wetland in poor condition, and convert it to a variety of wetland types in excellent condition. This would be done by eliminating grazing and haying of the area, and by using a variety of water management and vegetation planting techniques to develop the types of wetlands needed to mitigate the impacts to Rock Creek. The proposed methods to be used and the values to be gained at Egeria Creek are discussed in more detail in the Wildlife section of this chapter. All of the vegetation and wildlife values of the wetlands to be lost at Rock Creek could be attained by improvement of Egeria Creek lands.

5.2.3. Aquatic Biology. The loss of nine miles of excellent trout stream in the Rock Creek drainage and the reduction of self-sustaining populations below the dam are the adverse impacts that need to be considered for mitigation. As discussed for Vegetation, the area along Egeria Creek, just a few miles west of Rock Creek, is a good mitigation site for

wetlands. This section of Egeria Creek in this area has extremely limited trout populations and the habitat is in very poor condition due to grazing and haying up to the stream's banks. Banks are unstable and have probably contributed to the large amount of sand and silt in the substrate. Riparian trees or shrubs are nonexistent. Runs are the most common habitat type with riffles spaced at intervals of approximately every 100 yards.

Flow in Egeria Creek is close to that of Rock Creek, but no gaging station presently exists to compare actual measurements. According to BLM and Forest Service personnel, trout populations are known from Egeria Creek above and below the proposed mitigation area. This site is a good potential mitigation site because it is in need of considerable improvement and approximately 10 miles of the stream may be available. Present problems at Egeria Creek that prevent trout from becoming established appear to be related to poor physical habitat. It is possible that water quality may also be a problem. Therefore, water quality will be measured during 1987 to determine what factors, if any, are limiting. Records from the old USGS gaging station that was washed out in the 1970s will be reviewed to assess flow.

An IFIM analysis of the habitat will be conducted in the summer of 1987 to quantify present available habitat. The stream will also be sampled to determine present fish populations. The stream will be assessed in terms of potential habitat improvements and these improvements will be modeled with the IFIM approach in order to quantify the amount of WUA that could be gained in the stream. This will then be compared to the amount of WUA lost at Rock Creek to determine how much of the impact can be mitigated. Egeria Creek is expected to mitigate in the range 50-75 percent of the loss of the stream habitat to be inundated at Rock Creek. Total mitigation would probably not be possible due to the high quality of the Rock Creek habitat.

The water quality, IFIM and fish sampling studies will all be conducted in early 1987 and their results included in the Final EIS. If the Rock Creek Alternative is chosen by the Forest Service, additional work will be needed to fine tune the proposed mitigation at Egeria Creek. The first step would be to utilize the data to be collected in 1987, along with any additional information that may be needed, to develop a plan on how and where Egeria Creek would be improved to enable it to maintain a trout population. The plan would include goals, objectives, and estimated time-table for reaching the objectives. This plan would be developed in cooperation with the CDOW. Once the plan was prepared, it would be carried out and the stream monitored to document the improvement in fish habitat and populations. At least initially, Egeria Creek would be stocked, although the goal would be to develop a self-sustaining population.

Because Egeria Creek would be used for wetland, fishery, and wildlife mitigation, many of the potential habitat improvements would mitigate impacts in two or all three disciplines and costs of development could be shared. For example, the fisheries plan could be developed in conjunction with the wetlands/wildlife plan. Therefore, costs could be shared for plan development. The fisheries portion of the plan is estimated to cost $10,000.

Habitat improvement to the stream would be rather extensive. One major improvement would be planting riparian plant species along the streambanks. Costs for this have been included in the wetland/wildlife mitigation proposals. Elimination of grazing would also benefit the stream by allowing natural and planted riparian vegetation to expand. Other improvements may include various instream habitat structures to create pools and cover. Costs for habitat improvements could run as much as $100,000. Monitoring the stream biannually would cost $75,000 for the first 5 years.

Mitigation of the loss of the self-sustaining trout in Rock Creek below the dam would involve monitoring this section to determine if, in fact, a problem exists. Stocking of the area would be done when needed to maintain a fishable resource. Because the amount of habitat would actually increase due to the increased base flows from the dam, the amount of fish in the area could be greater than at present. Appropriate stocking levels would be determined by the CDOW. Costs for monitoring would be about $5,000 per year and would last for 5 years. Stocking would replace that presently done on Rock Creek within the reservoir basin, therefore no additional cost would occur. Using stocking to mitigate loss of a self-sustaining fish population would not replace all of the values lost. Therefore, the impact would not be totally mitigated.

5.2.4. Wildlife. The adverse impacts to wildlife likely to be incurred at the Rock Creek site were listed and quantified in Section 4.3.8.1. Of primary concern to wildlife is the potential loss of 486 acres of various types of wetlands and the wildlife values associated with those wetland habitats. Another significant impact would be the loss of 1086 acres of non-forested general wildlife habitat and the reduction in habitat capability of surrounding areas due to disturbance. A potentially significant impact would be the loss of migrating elk through ice on the reservoir.

As noted in the Vegetation section, several sites were reviewed as potential mitigation sites, but the Egeria Creek site was determined to have the most potential for mitigating wildlife, wetland, and fishery impacts. The site involves approximately 2100 acres of which about 500+ acres would be used for mitigating impacts involving the loss of wetlands and associated wildlife values, while about 1600+ acres are useful for mitigating impacts to general non-forested wildlife habitat. Detailed mitigation studies between the draft and final EIS will determine what portion of the 1,600 acres of general non-forested wildlife habitat is required to provide a buffer strip for the riparian zone and for non-forested habitat requirements.

Potential impacts at Rock Creek were expressed in terms of acres inundated or otherwise affected for certain wetland and upland habitat types. Impacts for the wildlife values associated with these types were expressed in terms of Habitat Units. Habitat Units (HUs) for lost wildlife values associated with the various wetland and upland types were determined using standard methods from the Habitat Evaluation Procedure (HEP) as defined by the U.S. Fish and Wildlife Service (1980). Following extensive field work in 1986 (Pekins and Hugie, 1986), the Habitat Suitability Indices (HSI) for indicator species at Rock Creek were calculated using

computer models (Hays and Heasley, 1985). The species selected were taken to be indicators of the habitat parameters that were deemed important and did not by themselves necessarily reflect a value. An HSI can vary from 0.0 to 1.0, 1.0 being the most suitable. The HSI is then multiplied by the number of acres of habitat for the indicator species within the area of concern. A separate technical report (Pekins and Hugie, 1986) details the HEP study conducted at Rock Creek. The HUs from the Rock Creek HEP study are presented in Table 5.2.1 and serve to quantify the mitigation goals for lost wildlife values.

HEP was subsequently used to determine the value of the habitat at Egeria Creek. HSIs for Egeria Creek were estimated based on several brief site visits, past history of the site, and the best available scientific knowledge. The HSIs were then multiplied by the actual acres of habitat present at Egeria Creek that had potential for being converted to the habitat types needed for mitigation. Results are shown in Table 5.2.1.

An estimate of the future value of Egeria Creek was made by using an HSI of 0.6-0.7 for the indicator species. The increase of the HSIs from the present to the post-management phase reflects habitat improvements that would occur following implementation of specific management actions. The estimated gain in HUs (HUs present after management minus HUs already present) is likely conservative because much of the Egeria Creek area could conceivably have HSI values less than 0.1 for several of the species being considered, and HSIs of over 0.7 are quite possible following management. The net gain in HUs for the area was determined by subtracting the number of HUs already present from the HUs estimated to be present after management. The net gain in HUs exceeded the mitigation goal for all but two species (Table 5.2.1). Therefore, the area has the potential of meeting the mitigation goals for these species depending on the type of management implemented and totally mitigating the impacts associated with wildlife values of wetlands and non-forested habitat.

To monitor the effectiveness of the Egeria Creek area as a mitigation site, a HEP study was conducted during June 1987. Once the HEP analysis is completed the calculated HSIs will replace those used in Table 5.2.1. Estimates for post-management HSIs will be part of the HEP study.

If the Rock Creek Alternative is selected, purchase of private lands at Egeria Creek could cost $1.1 million. Additional studies to fine tune the proposed mitigation would be required. A survey of the Egeria Creek area would be made to determine the precise location and type of improvement facilities including fences, water management facilities and vegetation planting. The cost for this proposed survey would be approximately $28,000.

A comprehensive strategic and operational management plan would be prepared following the survey of the area. The plan would describe what needs to be done, where and when. It will include goals, objectives and an estimated time-table for reaching those objectives. The plan would involve wildlife and wetlands for the Egeria Creek area. The total cost for writing the plan would be approximately $16,000.

Table 5.2.1
Summary of the Effectiveness of Using the
Egeria Creek Site in Meeting Mitigation Goals for
Wildlife Impacts Incurred at the Rock Creek Reservoir Site

Impact	From Reservoir HEP*			Present at Site			Post-Management			Net Gain	Need
	HSI	Acres	HUs	HSI	Acres	HUs	HSI	Acres	HUs	HUs	HUs
Wildlife Values for Wetland Species											
Elk	0.6	499	278	0.1	530	53	0.7	530	371	318	-40
Beaver	0.75	250	188	0.0	272	0	0.7	272	190	190	-2
Y. Warbler	0.59	250	148	0.0	272	0	0.7	272	190	190	-42
Non-Forested											
Elk	0.6	600	360	0.3	1514	454	0.6	1514	908	454	-94
Blue Grouse	0.74	600	444	0.3	1514	454	0.6	1514	908	454	-10
B. Sparrow	0.86	600	516	0.3	1514	454	0.6	1514	908	454	62

* HSI = Habitat Suitability Index, HU = Habitat Units (HU = HSI x Acres)

Management actions proposed for Egeria Creek and their relative cost are discussed below.

- Establish a water management system that would raise the ground-water level and create perennially wet meadow in selected areas. The wet soils would be conducive to establishing willows and other riparian habitat. One or two of the structures could create small ponds that would also mitigate the loss of 2 acres of beaver ponds at Rock Creek. Beaver could be introduced at a later date when the riparian community could support them. Creation of this habitat would benefit a large variety of wildlife species including passerines, waterfowl and aquatic furbearers. This would approximate the habitat lost at Rock Creek (See Table 5.2.1). Approximately 500 acres would be involved. Total cost for this type of management would be approximately \$64,000.

- Revegetate approximately 260 acres along stream banks with willow, aspen, alder and birch to establish riparian vegetation and create general wildlife habitat. Since very little riparian habitat is present at Egeria Creek, creation of 260 acres of this habitat type would essentially replace the 245 acres lost at Rock Creek. The unit cost is about \$140/acre (± 20%). Total cost for this type of management would be about \$34,000.

- Fencing to control grazing of domestic livestock on the site and eliminating haying on the Egeria Creek bottomlands and adjacent uplands would allow benefits from revegetation efforts would occur sooner. There would also be an increase in available forage and cover for wildlife, since many acres (perhaps in excess of 300) would likely revert naturally to productive wildlife habitat. Stream quality would also be improved. This would benefit several species of wildlife and would facilitate the management actions proposed above. Unit cost for fencing is about \$4,500/mile. Total cost for this type of management would be approximately \$54,000.

- Plant birch, alder, willows and aspen (perhaps cottonwoods) on approximately 32 acres of flood plain to re-establish shrub and arboreal habitats and their associated wildlife communities. This action would facilitate the use of the riparian and other habitats by a large variety of non-game birds, raptors, and other avian species. The proximity of arboreal habitats to the riparian and aquatic habitats at Rock Creek is within 0.5 mile compared to 1.0 mile at Egeria Creek. The establishment of trees near the proposed riparian habitat would make the Egeria Creek site more comparable to the Rock Creek area. Unit cost for planting trees is approximately \$300/acre (± 20%). This level of effort would provide about 800 stems per acre. Total cost for this action would be approximately \$9,600.

The area would be monitored biannually for at least 5 years to determine how well the management plan is being implemented and the effectiveness of the plan in meeting the prescribed mitigation goals and objectives. Total cost for monitoring the wildlife management actions and plan would be approximately \$65,000.

Total estimated cost for the management actions, surveys, planning and monitoring of the wildlife mitigation plan at Egeria Creek would be about $270,000 in addition to land purchase costs.

To mitigate the loss of habitat capability in forested areas, the Forest Service would restrict off-road travel in the area. Appropriate signs and increased enforcement would be utilized to reduce the amount of disturbance in the area. Due to the expected visitation at the campground/day use area, increased use of the forested area would still occur. Therefore, not all of the impact would be mitigated.

The potential impact of elk crossing a frozen reservoir and then falling through and being killed or injured will be monitored by the CDOW. If a problem actually occurs, appropriate action would be initiated. The probable mitigation would be installation of a fence to turn elk to one side of the reservoir or the other.

5.2.5. Grazing. The Blacktail Allotment would lose about 11 percent of its available forage as measured in AUMs. To mitigate this impact, additional forage would be available from the private land to be purchased near the proposed reservoir. Because this amounts to only about 50 acres, additional forage would need to be made available. The Forest Service would look for ways to provide this allotment with additional forage in the area.

5.2.6. Cultural Resources. A preconstruction survey of the reservoir basin and other areas to be disturbed would be conducted. Cost would be about $15,000. If any important sites that require excavation are located, the site would be excavated prior to disturbance of the site. Costs for this excavation would depend on the size and number of important sites located.

If the Stage Stop was not moved, the site would be excavated and recorded prior to inundation. The structure would probably be torn down to eliminate debris in the reservoir, and would not be available for future investigations, but the historical properties of the site would be recorded.

5.3. Muddy Creek Alternative

5.3.1. Surface Water. Changes to surface-water resources for Muddy Creek would be changes in streamflow resulting from reservoir operations. Impacts and mitigation would be related primarily to recreation and aquatic biology which are discussed separately below. During a severe drought period such as 1977-1978 reservoir operations would eliminate the conservation pool. During this dry period Muddy Creek would not be able to meet the full requirements of the Metro Denver Lease. There would be a shortfall of about 3,000 acre-feet which could require reducing the amount of water obligated under the lease.

5.3.2. Water Quality. There is a potential for water quality problems in Muddy Creek Reservoir. Water quality changes downstream and in the reservoir need to be better determined before specific mitigation can be proposed. Additional water quality monitoring and temperature (thermal) modeling during the design phase and the early years of reservoir operations would better quantify the potential water quality changes.

The post-construction monitoring program would target data acquisition to support characterizing the thermal balance and stratification in the reservoir, turbidity in and below the reservoir, downstream temperature conditions, and water quality parameters using nitrogen, phosphorus, and associated compounds as indicators. Turbidity, temperature, and nitrogen (N) and phosphorus (P) concentrations (as a measure of productivity) would be measured (1) at the reservoir inlet, (2) at the reservoir outlet, and (3) at various depths in the reservoir. In addition, conductivity measurements would be taken and related to total dissolved solids (TDS) at these three locations. The monitoring program would support relating variations in these parameters to reservoir operations.

To completely characterize the thermal conditions in the reservoir and develop the ability to predict potential impacts of reservoir operational alternatives would require water quality or thermal modeling. This modeling could be initiated during the design phase and refined after construction using the data acquired with the monitoring program. For example, the Corps of Engineers CE-THERM-R1 portion of CE-QUAL-R1 could be used to simulate temperature, suspended solids (SS), and total dissolved solids (TDS) in the reservoir. Data requirements would include:

- Physical characteristics of the reservoir (surface area, volume, outlet works

- Inflow data (discharge, temperature, SS, TDS)

- Meteorological data (dry and wet bulb temperature, wind speed, barometric pressure, cloud cover)

- Operational release data (projected or actual)

For Muddy Creek Reservoir thermal modeling would support developing release and operating procedures for the multi-level outlet works to control temperature of the release water.

5.3.3. Vegetation. Vegetation impacts due to the Muddy Creek Alternative include wetland losses and the potential significant loss of a candidate endangered plant, Osterhout's milkvetch. The potential mitigation of wetland impacts were handled very similarly to those discussed for Rock Creek. An interagency group was involved in determining the best of the sites from seven separate mitigation sites that were originally considered. Following a preliminary review, Pass, Antelope, upper Muddy, lower Troublesome, and upper Red Dirt creeks were discarded from consideration for a variety of reasons, mainly a lack of mitigation potential or insufficient size.

Areas that remained to mitigate wetlands included private lands to be purchased by the CRWCD around the reservoir, and lower Muddy Creek, a combination of BLM, State and private lands.

The CRWCD must acquire certain private lands within and adjacent to the proposed reservoir in order to maintain management options and properly operate the reservoir. Some of these lands that are adjacent to the reservoir present opportunities for use in meeting mitigation goals associated with impacts to wetlands. The areas in this category include approximately 30 acres west of Highway 40 along Pass Creek, about 20 acres west of the edge of the reservoir along Red Dirt Creek and about 20 acres north of the reservoir along Muddy Creek.

Approximately 575 acres of the proposed lower Muddy Creek mitigation site is of prime interest for mitigating wetland associated impacts. Of those acres, approximately 245 acres are managed by the BLM, 200 acres are privately owned and 130 acres are owned by the State of Colorado. The site has an average elevation of about 7350 feet. Several landowners are involved with the 200 acres of private land. Nearly all of acreages involved are used for the grazing of cattle and horses, either privately or as part of Federal or State grazing leases. The 200 acres of private land are part of three larger ownership blocks that total approximately 640 acres. It is likely that an entire block would have to be purchased to obtain the area of interest.

The creek has degraded considerably, leaving many sections of stream bank high and dry. The area has been very heavily grazed by wild and domestic ungulates. Consequently, most of the riparian habitat is in relatively poor condition. Opportunity exists to replace the willow and cottonwood riparian habitat on the private or government lands and to reorient the management of other bottomlands in order to facilitate restoration of the riparian zone. The acres of interest could also be managed to replace some of the lost acres of naturally and artificially irrigated meadow. There is ample room for establishing small ponds, slow moving stream and cattail habitat within the bottomlands on the privately owned land.

As discussed for Rock Creek, quantification of wetland values on the areas to be impacted has been accomplished using HEP procedures. HEP values were estimated to quantify the value of the mitigation site and a followup HEP study will be conducted in June 1987 to fine tune the proposed mitigation plan. This assessment will be included in the Final EIS.

The two sites provide the opportunity to utilize existing wet subirrigated meadow wetlands in poor condition, and convert them to a variety of wetland types in excellent condition. This would be done by eliminating grazing and haying of the area, and by using a variety of water management and vegetation planting techniques to develop the types of wetlands that would mitigate the Muddy Creek impacts. The proposed methods to be used and the values to be gained at the two sites are discussed in more detail in this chapter under Wildlife. It is expected that most of the vegetation and wildlife values of the wetlands to be lost at Muddy Creek could be attained by improvement of the lands around the reservoir and below the dam.

To determine the specific extent of the impact to Osterhout's milk-vetch, the location of the shoreline associated with the normal maximum operating level of the reservoir was accurately level-surveyed in the vicinity of known populations of the plant in June 1987. The area containing the species that would be inundated was accurately determined and and significance of the impact will be discussed in more detail in the FEIS. One potential mitigation strategy is the construction of dikes to protect the species from inundation. The dikes could be constructed at the heads of "reservoir fingers" where populations of the species occur along the proposed shoreline. Approximately 0.6 miles of cumulative linear distance of dikes could be required at an approximate cost of $100,000. Diversion structures could be constructed to convey runoff in the drainages around the dikes to prevent the accumulation of surface water on the upslope side of the dikes for an approximate cost of $10,000. Total cost of implementing this measure could be approximately $110,000.

Another mitigation technique may be transplantation of individual plants to suitable habitat not impacted by the project, which would have an approximate cost of $5,000.

The areas containing the species around the shoreline would be secured from trampling by people using the reservoir shoreline by constructing fences. Approximately 4.5 miles of fencing would be required for a total of $18,000.

Recreation and recreation site development, as well as grazing, would not be allowed on CRWCD land (to be purchased) adjacent to the reservoir in areas containing the species. Some minor fencing would be implemented and tied into the fencing discussed above.

5.3.4. Wildlife. The adverse impacts to wildlife that would likely be incurred at the Muddy Creek site were listed and quantified in Section 4.4.8.1. A significant impact to wildlife identified in that section is the potential loss of 810 acres of various types of wetlands and the wildlife values. Another significant impact would be the loss of 1272 acres of big game winter range and the related adverse impacts associated with placing a large reservoir within an important big game wintering area. Briefly, these adverse impacts include loss of forage, loss of cover and concealment, increased mortality from vehicle collisions, mortality from ice hazards, increased stress and loss of general winter living space.

Several options were investigated that would address mitigation of the above noted impacts. Seven separate mitigation sites were considered. Following a preliminary review, Pass, Antelope, upper Muddy, lower Troublesome, and upper Red Dirt creeks were discarded from consideration for a variety of reasons, mainly a lack of mitigation potential or insufficient size.

Following a review of the mitigation goals for wildlife for the proposed sites available for use in meeting those goals, it was determined that a combination of sites would be needed. The sites recommended for use include: (1) lower Muddy Creek, the area below the proposed dam site to within about 0.5 miles of Kremmling; (2) portions of the private lands

acquired by the Colorado River Water Conservation District (CRWCD) needed for reservoir operation; (3) BLM lands to the south and north of Wolford and Little Wolford Mountains; and (4) spaces for signs within the right-of-way along U.S. Highway 40. A description of these sites and their potential use in mitigating impacts to wildlife associated with loss of wetland habitat at Muddy Creek is presented below.

5.3.4.1. Lower Muddy Creek. Approximately 575 acres of the proposed lower Muddy Creek mitigation site is of prime interest for mitigating wetland associated impacts. Of those acres, approximately 245 acres are managed by the BLM, 200 acres are privately owned and 130 acres are owned by the State of Colorado. The site has an average elevation of about 7350 feet. Several landowners are involved with the 200 acres of private land. Nearly all of acreages involved are used for the grazing of cattle and horses, either privately or as part of Federal or State grazing leases. The 200 acres of private land are part of three larger ownership blocks that total approximately 640 acres. It is likely that an entire block would have to be purchased in order to obtain the acres of interest at a cost of about $600,000.

The creek has degraded considerably, leaving many sections of stream bank high and dry. The area has been very heavily grazed by wild and domestic ungulates. Consequently, most of the riparian habitat is in relatively poor condition. Opportunity exists to replace the willow and cottonwood riparian habitat on the private or government lands and to reorient the management of other bottomlands in order to facilitate restoration of the riparian zone. The acres of interest could also be managed to replace some of the lost acres of naturally and artificially irrigated meadow. There is ample room for establishing small ponds and slow moving stream and cattail habitat within the bottomlands on the privately owned land. All 575 acres of bottomland being considered plus additional acreage upslope could be improved for wintering big game animals, particularly deer. However, improvement on the flat bottomlands would not be the first choice for improving winter range but it would be a side benefit. A summary of the effectiveness of using the lower Muddy Creek site is presented in Table 5.3.1.

Potential impacts at Muddy Creek were expressed in terms of acres inundated or otherwise affected for certain wetland and upland habitat types, but the wildlife values associated with these types were expressed in terms of Habitat Units. The reader is referred to Section 5.2.4 for a discussion on Habitat Units (HUs) and interpretation of the information in Table 5.3.1. The same assumptions and techniques referred to in the section on Rock Creek apply to Muddy Creek. A separate technical report (Pekins and Hugie, 1986) details the HEP study conducted at Muddy Creek to determine the HUs present at the proposed reservoir site. Potential HUs for two of the three indicator species would exceed the mitigation requirements, but HUs for the third species would not be compensated (Table 5.3.1). This is due to the large number of acres of wet meadow in poor condition lost at Muddy Creek and the relatively small amount of wet meadow at the mitigation sites. The large increases in HUs is a reflection of the woody riparian vegetation which would be developed at the mitigation sites.

Table 5.3.1
Summary of Effectiveness of Lower Muddy Creek in Mitigating Wildlife Impacts Associated with Wetland Habitat Losses at Muddy Creek

Impacts	From Reservoir HEP*			Present at Site			Post-Management			Net Gain	Need
	HSI	Acres	HUs	HSI	Acres	HUs	HSI	Acres	HUs	HUs	HUs
Wildlife Values for Wetland Species											
Elk	0.39	783	305	0.2	515	103	0.7	515	361	258	47
Beaver	0.50	36	18	0.2	235	47	0.7	235	165	118	-100
Y. Warbler	0.35	36	13	0.2	215	43	0.7	215	151	108	-95

* HSI = Habitat Suitability Index, HU = Habitat Units (HU = HSI x Acres)

Because woody riparian areas are generally favored by more wildlife species than are wet meadows, the net surplus in HUs for the two species would help compensate for the net HU requirement of the one species. Although not totally a 1:1 replacement, wildlife and wetland values would be mitigated with this tradeoff, according to standard HEP procedures. A HEP study was conducted on the potential mitigation sites during June 1987. Once the HEP analysis is completed the calculated, HSIs will replace those used in this wildlife mitigation section.

If the Muddy Creek Alternative is selected, additional studies to fine tune the proposed mitigation would be conducted. A survey of the lower Muddy Creek area would be made to determine precise locations of improvement facilities including fences, water diversion facilities (if any), plantings and range improvement efforts. Total cost for this proposed survey would be approximately $28,000.

A comprehensive strategic and operational management plan would be prepared following a survey of the area. The plan would describe what needs to be done, where and when. It would include goals, objectives and an estimated time-table for reaching them. Total cost for development of the plan would be approximately $16,000.

The types of habitat management proposed for the lower Muddy Creek site, expected gains in meeting mitigation goals, and cost estimates are presented below.

- Establish a water management system that would raise the ground water level and create perennially wet meadow in selected areas. The wet soils would be conducive to establishing willows and other riparian habitat. Several small ponds that are 2 to 5 acres in size would be established in order to mitigate the loss of 7 acres of standing water at Muddy Creek. Creation of these habitat types would benefit a large variety of wildlife species including passerines, waterfowl and aquatic furbearers and would approximate the best habitat lost at Muddy Creek. Approximately 400 acres would be involved. Total cost for this type of management would be approximately $48,000.

- Revegetate approximately 50 acres along stream banks with willows, alder, aspen, cottonwoods, and birch to stabilize the banks and create general wildlife habitat. Existing riparian habitat would be improved by direct and indirect management such as planting, burning, and reducing use by cattle. This would be done within some of the area created with the water management program referred to above. Because very little riparian habitat present at lower Muddy Creek is in excellent or even good condition, creation of 50 acres of new riparian habitat and revitalization of the existing habitat should easily replace the 36 acres lost at Muddy Creek. The unit cost is about $300/acre (± 20%). Total cost for this type of management would be about $10,800.

- Fence bottomlands and remove livestock grazing but allow corridors to the stream for watering. By substantially altering the grazing program for domestic livestock on the BLM, private, and State lands in

the river bottomlands, and eliminating haying from the lower Muddy Creek bottomlands, benefits from revegetation efforts would occur sooner. There would also be an increase in available forage and cover for wildlife, especially wintering big game. This would benefit several species of wildlife and would facilitate the management actions proposed above. Without heavy grazing pressure or haying, many acres (perhaps in excess of 300) would likely revert to productive wildlife habitat. Redistribution of grazing on BLM lands would be achieved by developing water, adding salt stations, and improving range conditions on the affected allotment. Unit cost for fencing is about $4,500/mile. Total cost for this type of management would be approximately $45,000 plus another $30,000 for improvements on BLM land.

- The uplands adjacent to lower Muddy Creek are within various categories of important big game winter range. The carrying capacity of the BLM, State, and private lands could be increased substantially by selective treatment of appropriate areas with herbicide and fertilizer. Approximately 125 to 175 acres would fall into this category for management. The areas to be fertilized would be identified with the aid of the CDOW in the spring of 1987 and detailed in the FEIS. The unit cost for this type of management would be approximately $200/acre. Total cost would be about $35,000.

- The area would be monitored bi-annually for at least 5 years to determine how well the management plan was being implemented. The effectiveness of the plan in meeting the prescribed mitigation goals and objectives would also be assessed. Total cost for monitoring the wildlife management actions and plan would be approximately $65,000.

Total estimated cost for the management actions, surveys, planning and monitoring of the mitigation plan at lower Muddy Creek would be about $280,000. Purchase of private lands below the dam could cost another $600,000.

5.3.4.2. <u>CRWCD Acquired Lands</u>. The CRWCD must acquire certain private lands within and adjacent to the proposed reservoir in order to maintain management options and properly operate the reservoir. Some of these lands that are adjacent to the reservoir present opportunities for use in meeting mitigation goals associated with impacts to wildlife. The areas most likely to be in this category include approximately 30 acres west of Highway 40 along Pass Creek, about 20 acres west of the edge of the reservoir along Red Dirt Creek and about 20 acres north of the reservoir along Muddy Creek. In addition, approximately 200 acres of the CRWCD lands are within big game winter range and could be managed to benefit big game. The total acreage of private land that would be acquired is approximately 1600. The total acres useful for mitigation are about 270.

The effectiveness of using the CRWCD lands to mitigate impacts to wildlife associated with the loss of wetlands is summarized in Table 5.3.2.

Table 5.3.2
Summary of Effectiveness of Using CWRCD Lands in Mitigating Wildlife Impacts Associated with Wetland Habitat Losses at Muddy Creek

Impacts	From Reservoir HEP*			Present at Site			Post-Management			Net Gain	Need
	HSI	Acres	HUs	HSI	Acres	HUs	HSI	Acres	HUs	HUs	HUs
Wildlife Values for Wetland Species											
Elk	0.39	783	305	0.3	70	21	0.6	70	42	21	284
Beaver	0.50	36	18	0.3	70	21	0.6	70	42	21	-3
Y. Warbler	0.35	36	13	0.3	70	21	0.6	70	42	21	-8

* HSI = Habitat Suitability Index, HU = Habitat Units (HU = HSI x Acres)

The types of management actions considered for the CRWCD lands are similar to those described for lower Muddy Creek, namely:

- Establish a water management system that would help to create conditions conducive to establishing wet meadow habitats. Total cost would be about $8,000 for the entire 70 acres involved. Principle benefits would be for species using sub-irrigated wetland but other species such as big game and passerines would also likely benefit.

- Grazing would be reduced or eliminated during the period that the habitats were being restored. After that it would be used as a management tool. Costs would be related to fencing and would likely not exceed $10,000.

- The uplands adjacent to the northeast end of the reservoir are designated as big game winter range. This land has some potential for use in mitigating the impact to big game. Carrying capacity on this land could be increased through selective application of herbicide and fertilizer. Approximately 25-30 acres would be involved at a cost of $100/acre. Total cost would be approximately $3,000.

The survey, planning and monitoring programs described for lower Muddy Creek would also be done for the CRWCD lands. Total cost for this phase of the mitigation plan is included in the lower Muddy Creek monitoring costs. Total mitigation costs, not including land acquisition, for the CRWCD lands would be about $21,000.

5.3.4.3. <u>North and South of Wolford and Little Wolford Mountains</u>. Managing bottomlands to re-establish or improve wetland habitat quality would provide some benefits to big game but they would be incidental to providing habitat for other species. However, it should be recognized that improvements to riparian, arboreal and other habitats would provide cover, shelter and forage for big game.

The primary means of mitigating the impacts to big game winter range would be the enhancement and development of appropriate forage on about 800 acres of land within the CDOW designated big game wintering area. South of Wolford Mountain, about 100 acres of private land and 300 acres of BLM land would be needed. The private land would be part of the lands acquired for the lower Muddy Creek mitigation site. The BLM land is part of grazing allotment #7658. Presently, the 400 acres are used for grazing cattle and horses during the spring and summer. In addition, another 400 acres north and on top of Little Wolford Mountain in BLM grazing allotment #7506 would be needed. This acreage is used for spring grazing of cattle. The types of management intended for this acreage are described below.

- Following a detailed survey of the area in the spring of 1987 to identify areas with potential for improvement, certain slopes and portions of the allotment and private land would be selectively treated with herbicide and/or fertilizer according to procedures agreed to by the Kremmling District Office of the BLM and CDOW personnel. Carrying capacity can be substantially increased by this type

of management. Cost would be about \$100/acre for herbicide and fertilizer treatment and \$50/acre for just fertilizing. The acreages south of Wolford Mountain would be treated with both herbicide and fertilizer while the acreage north of Little Wolford Mountain would be treated with fertilizer only. Approximate total cost for treating the 800 acres would be \$60,000.

- BLM allotment #7658 is operated according to a plan that was amended in September 1986. Several projects were presented in that plan for future implementation which would expedite the recovery of the range in the allotment and the adjoining riparian areas along Muddy Creek. For instance, the fencing and restoration of Cow Gulch and establishing watering devices to maintain control and separation of livestock. The important elements of that plan that would directly benefit big game should be implemented on an accelerated schedule. Costs for these improvements were included in the lower Muddy Creek discussion.

- In order to attract and hold big game near the proposed range improvements south of Little Wolford Mountain, several unprotected stacks of hay could be placed near the acreages that had been fertilized. The objective would be to provide an attractant to the animals and keep them to the east of the reservoir, away from ranchers haystacks, Highway 40, and possible dangers of the reservoir itself. This technique would be used for 1 or 2 years after the reservoir was filled in order to habituate big game to the newly revitalized food resources. Cost for this action would be about \$20,000/year for a total of \$40,000.

- Construct stack guards for the three to six haystacks at the north end of the proposed reservoir on private property. This mitigation is directed at reducing impacts associated with big game depredation on haystacks due to increased movement of big game around the north end of the reservoir. Cost would be approximately \$8,000.

- Space would be needed to erect three or four signs along Highway 40 between Pinto Creek and Kremmling. At least two of the signs would be electrically animated. The central theme or message to motorists would be that there is an extreme danger in this area and that colliding with a big game animal could result in severe property damage and personal injury. This mitigation is directed at reducing impacts associated with big game highway mortality. Costs for constructing, erecting and maintaining the signs would be about \$30,000.

5.3.4.4. Mitigation Summary. Use of the Muddy Creek bottomlands, the CRWCD land and upland areas administered by the BLM would provide total mitigation of wildlife impacts. Using the HEP analysis for wetland areas and combining the HUs for lower Muddy Creek and CRWCD lands, elk HUs would still be 89 units short, but beaver would have an excess of 94 units and yellow warbler an excess of 90 units. As discussed above, the surplus in the two species would offset the need in the one species.

5.3.5. Cultural Resources. Mitigation measures would be the same as discussed for the Rock Creek Alternative.

6.0. LIST OF PREPARERS

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6.0. LIST OF PREPARERS

The individuals listed below had primary responsibility in preparing the Rock Creek/Muddy Creek Reservoir EIS. Their education, project responsibilities, qualifications, and experience are briefly summarized.

6.1. U. S. Forest Service, Routt National Forest, Steamboat Springs, Colorado

Ed Ryberg

Education - B.S., Political Science, University of Utah; M.F., Forest Management, Utah State University; Forest Service Fellowship in Resource Economics, Michigan State University.

Project Responsibility - NEPA/Environmental Coordination and Economics.

Experience - 10 years of varied experiences and responsibilities with the USDA Forest Service.

Raymond Brown

Education - at Stephen F. Austin

Project Responsibility - Provide management concerns and resource information.

Experience - 8 years on two Ranger Districts in Recreation, Lands, Minerals, Fire, and Timber Management; 9 years as District Ranger on three forests (11 years on the Carson National Forest, 2 years on the Tongass National Forest, and 5 years on the Routt National Forest).

James Jaminet

Education - B.S., Forest Management, Iowa State University; National Forest Recreation Management Correspondence Study, Colorado State University.

Project Responsibility - Forest Service Project Coordinator and Recreation review.

Experience - 2 years as Forestry Technician and 8 years as Forester in varied capacities with USDA Forest Service.

Sherry Reed

Education - B.S., Wildlife and Fisheries Biology, University of California at Davis.

Project Responsibility - Wildlife, Vegetation, Wetlands, Threatened and Endangered.

Experience - 10 years as a Wildlife Biologist, USDA Forest Service.

Garret Decker

Education - B.S., Watershed Management, Colorado State University, 1979.

Project Responsibility - Surface Water Resources, study design and review.

Experience - 3 years Hydrologic and Hydraulic Engineering Technician and 4 years Forest Hydrologist with USDA Forest Service.

Bob Stuber
Education - B.S., Zoology, Univerity of Wisconsin-Madison; M.S., Fishery and Wildlife Biology, Colorado State University.
Project Responsibility - Aquatic Biology, Fish Habitat.
Experience - 7 years Fisheries Biologist, USDA Forest Service; 2 years Fisheries Technician, U.S. Fish and Wildlife Service; 1 year Wildlife Technician, Colorado Division of Wildlife.

Robert H. Nykamp
Education - B.A., Anthropology, University of Colorado.
Project Responsibility - Cultural resource compliance, report review.
Experience - 5 years archeologist, USDA Forest Service; 7 years teaching and archeological contract work.

Loren Kroenke
Education - B.S., Forestry, University of Minnesota
B.S., Soil Science, University of Minnesota.
Project Responsibility - Soils and Geology.
Experience - 7 years Forest Soil Scientist, USDA Forest Service; 1 year Soil Scientist, USDA Soil Conservation Service.

John Costello
Education - BLA, Landscape Architecture and Environmental Planning.
Project Responsibility - Member of Interdisciplinary Team representing recreation and visual resources.
Experience - 10 years Landscape Architect; 1 year with Bureau of Land Management; 9 years with USDA Forest Service in two supervisors' offices.

Robert M. Sprentall
Education - B.S., Range-Forest Management, Colorado State University.
Project Responsibility - Range Management/Forest Service Project Coordinator.
Experience - 2 years Range Technician and 8 years Range Conservationist, USDA Forest Service.

6.2. U. S. Bureau of Land Management, Kremmling Resource Area, Kremmling, Colorado

Charles J. Cesar
Education - B.S., Wildlife Biology, Colorado State University.
Project Responsibility - Wildlife Habitat, Project Coordinator BLM.
Experience - 13 years as Wildlife Management Biologist, BLM; 1 year as Wildlife Technician, BLM; 2 years private industry.

Paula E. Ledford
Education - B.S., Watershed Science, Colorado State University.
Project Responsibility - Hydrology
Experience - 1 year Cooperative Education Hydrologist, BLM; 2 years Hydrologist, BLM.

Priscilla E. Mecham
Education - B.S., Anthropology/Archaeology, State University of New York at Albany.
Project Responsibility - Project Coordinator, BLM.
Experience - 5½ years Archaeologist, BLM; 3 years Multi-Resources Staff Leader, BLM.

Steven Romoff
Education - B.S., Recreation Planning and Environmental Interpretation School of Forestry, Oregon State University.
Project Responsibility - Recreation
Experience - 2 years Interpretive Naturalist, Park Science; 1 year River Ranger, BLM; 4½ years Recreation Specialist, BLM; 2½ years Outdoor Recreation Planner, BLM.

6.3. Resource Consultants, Inc., Fort Collins, Colorado

Peter F. Lagasse - President
Education - B.S., Engineering, U.S. Military Academy; M.S., Civil/Hydraulic Engineering, University of California at Berkeley; Ph.D., Hydraulic Engineering/River Mechanics, Colorado State State University.
Project Responsibility - Project Manager.
Experience - 20 years with U.S. Army Corps of Engineers and 7 years consulting in hydraulic engineering and management of NEPA compliance projects.

David M. Frick - Vice President for Engineering
Education - B.S. and M.S., Civil Engineering, Colorado State University.
Project Responsibility - Reservoir Operations modeling and post-project Hydrology.
Experience - 15 years consulting in hydrology and hydraulics.

James D. Schall - Senior Water Resources Engineer
Education - B.S., Interdisciplinary Engineering, Purdue University; M.S., Civil Engineering, Colorado State University; Ph.D., Civil Engineering, Colorado State University.
Project Responsibility - Channel Hydraulics, Channel Stability, and Channel Maintenance Flow.
Experience - 7 years consulting in hydraulics and river engineering.

E. Bruce Jones - Senior Water Resources Engineer
Education - B.S., Civil Engineer, University of Wyoming; M.S., Meteorology, Pennsylvania State University; Ph.D., Watershed Management, Colorado State University.
Project Responsibility - Existing Condition Hydrology.
Experience - Applied research and consulting in surface-water hydrology, remote-sensing hydrology, and climatological analysis.

John Stednick - Assistant Professor, Department of Earth Resource, Colorado State University.
Education - B.S., Forest Science/Management, University of Washington; Ph.D., Hydrology, University of Washington.
Project Responsibility - Water Quality/Air Quality analysis.
Experience - Teaching, research, and consulting in land use, water quality analysis, and environmental impact assessment.

6.4. BIO/WEST, Inc., Logan, Utah

Paul Holden - Principal and Aquatic Ecologist
Education - B.S., Conservation and Biology, Wisconsin State University; M.S., Fishery Biology, Utah State University; Ph.D., Wildlife Biology, Utah State University.
Project Responsibility - Assistant Project Manager and Aquatic Biology Analysis.
Experience - 20 years research, teaching, and consulting in wildlife science, aquatic biology, habitat of rare fishes of the Upper Colorado River Basin, and management of NEPA compliance projects.

Oliver J. Grah - Soils and Vegetation Specialist
Education - B.S., Botany, California State University at Chico; M.S., Forest Resources, Utah State University.
Project Responsibility - Soils and Vegetation analysis.
Experience - 8 years experience in research and consulting.

Roy Hugie - Wildlife Biologist
Education - B.S., Wildlife Biology, Utah State University; M.S., Wildlife Management, University of Maine; Ph.D., Forestry, University of Montana.
Project Responsibility - Wildlife and Grazing analysis, analysis of Cumulative Impacts and Mitigation.
Experience - 10 years as Wildlife Biologist with Maine Department of Inland Fisheries and Wildlife and 9 years research and consulting in wildlife biology.

Roni Slavin Pekins - Wildlife/Environmental Analyst
Education - B.A., American Studies, Cornell University; M.S., Wildlife Ecology, University of New Hampshire.
Project Responsibility - Wildlife and Land Use analysis.
Experience - 5 years experience in research and consulting.

Richard Krannich - Sociologist
Education - B.A., Sociology, Kent State University; M.S., Sociology, Utah State University; Ph.D., Sociology, Pennsylvania State University.
Project Responsibility - Social and Recreational analysis.
Experience - 12 years research, teaching, and consulting in sociology and recreation impacts analysis.

John Keith - Resource and Regional Economist
Education - B.S. and M.S., Range Science, Utah State University; M.A., Economics, Utah State University; Ph.D., Economics, Utah State University.
Project Responsibility - Economic analysis.
Experience - 17 years research, teaching, and consulting in systems analysis and economics.

Craig Johnson - Landscape Architect
Education - B.S., Landscape Architecture, Michigan State University; M.S., Landscape Architecture, University of Illinois; M.S., Fisheries and Wildlife Biology, South Dakota State University.
Project Responsibility - Visual Resource analysis.
Experience - 20 years experience in teaching and consulting.

Paul Nickens - Archaeologist
Education - B.A., Anthropology, University of Colorado; M.A., Anthropology/Archaeology; Ph.D., Archaeology, University of Colorado.
Project Responsibility - Cultural and Paleontological Resource analysis.
Experience - 14 years research, teaching, and consulting.

Gerald Hughes - Cartographer
Education - B.A., Geography, California State University at Fullerton.
Project Responsibility - preparation of maps and figures.
Experience - 10 years experience in Cartography.

6.5. Colorado River Water Conservation District, Glenwood Springs, Colorado

David H. Merritt - Senior Water Resources Engineer
Education - A.B., Earth Sciences, Dartmouth College; A.M., Geology, Dartmouth College.
Project Responsibility - Reservoir operations and hydrology.
Experience - 11 years in river/reservoir operations and water quality, including 3 years with Corps of Engineers and 5 years with Bureau of Reclamation, 2 years with Colorado River Water Conservation District.

Richard E. Kuhn - Assistant Secretary-Engineer
Education - B.S., Engineering Science, University of New Mexico; M.B.A., Pepperdine University.
Project Responsibility - Project history, institutional issues.
Experience - 6 years, Colorado River Water Conservation District.

7.0. CONSULTATION WITH OTHERS

7.0. CONSULTATION WITH OTHERS

The scope of environmental issues to be addressed in this Environmental Impact Statement and the alternatives for analysis were developed in close coordination with numerous agencies and individuals. Attempts to inform and involve the public were directed to all groups which might have an interest in either the Rock Creek or Muddy Creek alternative.

Consultation and coordination have included pre-scoping and public scoping meetings, as well as meetings on issues and status of the environmental statement and mitigation planning with interested Federal and State agencies. A synopsis for each public scoping meeting was prepared and circulated to cooperating and interested agencies. The list of issues in Section 1.6.2 is a direct result of the scoping process. The following specific coordination and consultation activities have taken place.

Summer 1985 - - - - -	Pre-scoping meetings between Forest Service and interested Federal and State agencies (including those considered as candidates for cooperating agency involvement).
July 31, 1985 - - - -	Public scoping meeting in Kremmling, Colorado.
August 1, 1985- - - -	Public scoping meeting in Yampa, Colorado.
August 2, 1985- - - -	Public scoping meeting in Denver, Colorado.
September 3-5, 1985 -	EIS coordination meeting in Steamboat Springs, Colorado with Bureau of Land Management (BLM), U.S. Fish and Wildlife Service (USFWS), Environmental Protection Agency (EPA), U.S. Army Corps of Engineers (COE), and Colorado Division of Wildlife (CDOW).
September 10, 1985- -	Meeting in Denver with Bureau of Reclamation and representatives of Boyle Engineering (under contract to Colorado Water Resources and Power Development Authority) to discuss hydrologic and reservoir operation modeling.
September 26, 1985- -	Wildlife Work Group meetings in Kremmling, Colorado, and Steamboat Springs, Colorado, with BLM, USFWS, COE, and CDOW.
September 27, 1985- -	EIS management meeting in Steamboat Springs with BLM.
October 9, 1985 - - -	Final scope of work for EIS distributed to cooperating agencies for review and comment.
October 10, 1985- - -	Special scoping meeting in Frisco, Colorado, for representatives of the Denver Water Board and Metropolitan Water Providers.

November 25, 1985 - - Wildlife Work Group meeting in Kremmling, Colorado, with USFWS, BLM, COE, and CDOW.

January 9, 1986 - - - EIS coordination meeting on recreation issues in Yampa, Colorado, with BLM.

January 10, 1986- - - EIS management meeting in Yampa, Colorado, with BLM.

February 10-11, 1986- EIS coordination meeting in Steamboat Springs, Colorado, with USFWS, BLM, COE, EPA, CDOW, and Grand County.

March 27, 1986- - - - 404 Permit, wetlands, and mitigation meeting with COE in Grand Junction, Colorado.

May 6, 1986 - - - - - EIS coordination meeting in Steamboat Springs, Colorado, with BLM.

May 20, 1986- - - - Wildlife Work Group meeting in Steamboat Springs, Colorado, with USFWS, BLM, and CDOW.

May 25, 1986- - - - Meeting with Denver Water Board representatives in Denver, Colorado, on Blue River exchange hydrology.

June 20, 1986 - - - - EIS management meeting in Steamboat Springs, Colorado, with BLM.

July 22, 1986 - - - - EIS coordination meeting in Steamboat Springs, Colorado, with BLM and EPA.

August 27, 1986 - - - EIS management meeting in Steamboat Springs, Colorado, with BLM.

October 1, 1986 - - - Distribution of preliminary draft of Chapters 1-4 of EIS to cooperating agencies (and EPA and CDOW) for review.

October 29, 1986- - - Wildlife Work Group meeting on mitigation issues in Steamboat Springs, Colorado, with BLM, USFWS, COE, EPA, and CDOW.

October 30, 1986- - - Mitigation issues field trip in Rock Creek and Muddy Creek drainages to assess mitigation potential of various sites with BLM, USFWS, COE, EPA, and CDOW.

October 31, 1986- - - EIS management meeting in Steamboat Springs, Colorado, with BLM.

December 1, 1986- - - EIS management meeting in Steamboat Springs, Colorado, with BLM.

December 16, 1986 - - Mitigation issues and alternatives meeting in Grand Junction, Colorado, with BLM, USFWS, COE, and CDOW.

December 31, 1986 - - Meeting with BLM regional hydrologists at Muddy Creek to discuss channel stability concerns.

January 28, 1987- - - Colorado River Water Conservation District Board meeting in Silver Creek, Colorado (open to public). A summary of EIS issues, impacts, and proposed mitigation for both Rock Creek and Muddy Creek alternatives was presented.

February 4, 1987- - - Meeting on mitigation alternatives in Grand Junction, Colorado, with BLM, USFWS, COE, and CDOW.

February 9-10, 1987 - EIS management meetings in Steamboat Springs, Colorado, with BLM.

February 10, 1987 - - Meeting on mitigation alternatives in Kremmling, Colorado, with BLM, USFWS, and CDOW.

May 5-6, 1987 - - - - EIS management meetings in Steamboat Springs, Colorado, with BLM.

May 28, 1987- - - - - Joint USFS and BLM visit to Rock Creek and Muddy Creek sites.

May 28, 1987- - - - - Meeting with representatives of Trout Unlimited to discuss Rock Creek mitigation and visit Egeria Creek.

May 29, 1987- - - - - EIS management meeting in Steamboat Springs, Colorado, with BLM.

July 9, 1987- - - - - Meeting and site visit on mitigation measures with River District, BLM, COE, USFWS, and CDOW.

8.0. LIST OF AGENCIES, ORGANIZATIONS, AND PERSONS TO WHOM COPIES OF THE STATEMENT ARE SENT

8.0. LIST OF AGENCIES, ORGANIZATIONS, AND PERSONS TO WHOM COPIES OF THE STATEMENT ARE SENT

U. S. Congress - Colorado
- Honorable William Armstrong
- Honorable Tim Wirth
- Honorable Hank Brown
- Honorable Patricia Schroeder
- Honorable Ben Nighthorse Campbell
- Honorable Dan Schaefer
- Honorable Joel Hefley
- Honorable David Skaggs

Federal Agencies
- Advisory Council on Historic Preservation
- Department of the Interior
  - Bureau of Land Management
  - Bureau of Reclamation
  - National Park Service
  - Fish and Wildlife Service
  - Geological Survey
  - Bureau of Indian Affairs
  - Natural Resource Library
  - Division of Environmental Compliance
- Department of Agriculture
  - Soil Conservation Service
- Department of Defense - Corps of Engineers
  - Sacramento District
  - Omaha District
- Department of Transportation
  - (Secretarial Representative, Denver, Colorado Federal Highway Administration)
- Environmental Protection Agency (Denver, CO)
- Environmental Protection Agency (Washington, DC)
- National Oceanic and Atmospheric Administration
  - (Ecology and Conservation Division)

State of Colorado
- Colorado Governor's Office, Director, Intergovernmental Relations
- Northern Colorado Water Conservancy District
- Middle Park Water Conservancy District
- Northwest Colorado Council of Governments
- State Planning Coordinator
  - (Department of Local Affairs - Colorado Division of Planning)
- Department of Natural Resources
  - Division of Wildlife
  - Division of Water Resources
  - Colorado Water Conservation Board
  - Colorado Geological Survey
  - Colorado Division of Parks and Outdoor Recreation

Department of Health
- Water Quality Control Division
- Air Pollution Control Division

State Historical Society of Colorado
Colorado State Historical Preservation Officer
Colorado State Clearinghouse
Colorado Water Resource and Power Development Authority
Colorado Water Congress

Other Government Entities
- Northwest Colorado Council of Governments
- Routt County Regional Planning Commission
- Routt County Planning Department
- Grand County Regional Planning Department
- Western Area Power Administration

Board of County Commissioners
- Routt County
- Grand County

Cities and Towns - Governmental Entitites
- Town of Hot Sulphur Springs
- Town of Granby
- Town of Grand Lake
- Town of Kremmling
- Town of Yampa

Conservation and Environmental Entities
- Audubon Society
- Colorado Environmental Coalition
- Environmental Defense Fund
- Friends of the Earth
- Sierra Club
- The Wilderness Society
- Trout Unlimited
- Wilderness Society-Denver
- Rabbit Ears Audubon Society
- Resources for the Future
- Nature Conservancy
- Northwest River Alliance

Colorado Newspapers
- Denver Post
- Rocky Mountain News
- Middle Park Times
- Sky Hi News
- High Country News
- Steamboat Pilot

Educational Institutions
- Colorado State University
- University of Colorado

Others

- Musick and Cope
- Western River Guides Ass'n
- United Farm Agency
- Taussig Ranch, Inc.
- Riverside Ranch
- Grand River Ranch
- Denver Water Board
- Louisiana Pacific
- National Organization for River Sports
- Delaney & Balcomb P.C.
- Knorr Brothers
- Matheson Ranch
- Schall Ranches, Inc.
- Grand River Ranch Corporation
- Bambi Enterprises
- Ritschard Cattle Company
- Diamond Ranch
- Steur Ranch

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- Mary Jean Perry
- Phil McCrury
- Grady Culbreath
- Gary Hill
- Glenda Hill
- Ken Muller
- Jerome Rogers
- Mr. and Mrs. J. N. Nelson
- Roland G. Olderog
- David Fuller
- John and Roberta Rogers
- Mike Briscoe
- Arthur E. Foskitt
- Bruce O. Hoehn
- Mr. and Mrs. Richard W. Langley
- Jill D. Johnson
- Jackie Rodriquez
- Bob Baughman
- John W. Murphy
- Tom W. Stander
- Scott Ratcliff
- Al Marlowe
- Claus Muhlbauer
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Jerry Hulstrom
Ron Sechers
W. S. Ratcliff
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Steve Goff
Roy Ferguson, Jr.
Stuart H. Buehling
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Karl Marlowe

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Colorado State University Library
Craig Moffat County Library
Denver Public Library
Fraser Valley Library
Grand County Public Library
Jackson County Public Library

9.0. LITERATURE CITED

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Alexander, R. K., 1985, Archaeological Survey of Morrison-Knudsen Engineers, Rock Creek Dam Site B and Test Pits, Routt County, Colorado. Grand River Consultants Report 850426, Grand, Junction, Colorado.

Anderson, J., 1986, Endangered Species Specialist, USDI Fish and Wildlife Service Endangered Species Field Office, Grand Junction, Colorado. Personal communication with Oliver Grah, BIO/WEST, Inc., Logan, Utah.

Andrews, E. D., 1984, Bed-Material Entrainment and Hydraulic Geometry of Gravel-Bed Rivers in Colorado. Geological Society of America Bulletin, Vol. 95, pp 371-378.

Arthur, C. S., 1980, Final Report on the Archaeological Reconnaissance of Thirty-One Core Hole Locations in Middle Park, Grand County, Colorado. Reports of the Laboratory of Public Archaeology No. 37, Colorado State University, Fort Collins, Colorado.

Arthur, C., G. M. Holmes, R. E. Kainer, K. T. Jones, and C. H. Jennings, 1979, Archaeological Reconnaissance of the West-East Natural Gas Pipeline, Rio Blanco, Moffat, Routt, Grand, and Summit Counties, Colorado. Reports of the Laboratory of Public Archaeology No. 27, Colorado State University, Fort Collins, Colorado.

Athearn, F. J., 1976, Antiquities Site Inventory Form: MP-010. On file at Bureau of Land Management, Kremmling Resource Area, Kremmling, Colorado.

Behnke, R. J., and M. Zorn, 1976, Biology and Management of Threatened and Endangered Western Trouts. U. S. Forest Service General Tech. Report. Rm. 28.

Boettcher, A. J., 1972, Ground-Water Occurrence in the Northern and Central Parts of Western Colorado. Colorado Water Conservation Board, Water Resources Circular 15, 50 pp.

Bohn, C., 1986, Biological Importance of Streambank Stability. Rangelands 8:55-56.

Boyle Engineering Corporation, 1986, Draft Task 03 Initial Screening Report, Joint-Use Reservoir and Green Mountain Exchange Projects, for the Colorado Water Resources and Power Development Authority, Denver, Colorado, January.

Browne, Bortz and Coddington, 1982, The Contribution of Skiing to the Colorado Economy--Routt County Case Study. Country Ski Country, Denver, Colorado.

Butler, D. L., 1986, Sediment Discharge in Rock Creek and Sedimentation Rate of the Proposed Rock Creek Reservoir, Northwestern Colorado. Draft USGS Water Resources Investigation Report, Denver, Colorado.

Canfield, D. E., Jr., and R. W. Bachmann, 1981, Prediction of Total Phosphorus Concentrations, Chlorophyll a, and Secchi Depths in Natural and Artificial Lakes. Can. J. Fish. Aquat. Sci. 38:414-423.

Canter, L. W., 1985, Environmental Impact of Water Resources Projects. Lewis Publishers, Inc., Chelsea, MI, 352 pp.

Carpenter, L. H., R. B. Gill, D. J. Freddy, and L. E. Sanders, 1979, Distribution and Movements of Mule Deer in Middle Park, Colorado. Colorado Division of Wildlife Spec. Rep. No. 46, 32 pp.

Carpenter, L. H., R. B. Gill, D. L. Baker, and N. T. Hobbs, 1984, Colorado's Big Game Supplemental Winter Feeding Program. Colorado Division of Wildlife, 92 pp.

Carpenter, L. H., 1976, Middle Park Cooperative Deer Study--Deer Habitat Evaluation. Colo. Div. Wildlife Game Res. Div. Fed. Aid Project W-38-R-31. Game Res. Report, July, Part 2, pp. 285-298.

Cesar, C., 1987, Wildlife Biologist, Kremmling Resource Area, USDI Bureau of Land Management, Kremmling, Colorado. Personal communication with Oliver Grah, BIO/WEST, Inc., Logan, Utah.

Chanson, S. B., 1985, Elk Migration Survey. Report submitted to BIO/WEST, Inc., December 1985.

Chanson, S. B., 1986, Winter Raptor Survey. Report submitted to BIO/WEST, Inc., February 1987.

Colorado Dept. of Health, 1984, Colorado Air Quality Data Report, State of Colorado, Denver, Colorado, 75 pp.

Colorado Dept. of Health, 1986, Classification and Numeric Standards Upper Colorado River Basin and North Platte River (Planning Region 12). Colorado Dept. of Health, Water Quality Control Commission, Denver, Colorado.

Colorado Division of Parks and Recreation, 1984a, The 1983 Statewide User Survey (of State Parks Use). Colorado Dept. of Natural Resources, Denver, Colorado.

Colorado Division of Parks and Recreation, 1984b, Williams Fork Area Management Plan. Colorado Department of Natural Resources, Denver, Colorado.

Colorado Division of Wildlife, 1984, Colorado Small Game, Furbearer, and Varmint Harvest. PR W-121-R, Wildlife Services Section, Colorado Div. Wildlife, Dept. of Natural Resources, Denver, Colorado.

Colorado Division of Wildlife, 1985, Colorado Big Game Harvest, 1984. PR 45-01-513, Colorado Department of Natural Resources, Denver, Colorado.

Colorado Ski Country U.S.A., 1982a, The Contribution of Skiing to the Colorado Economy, Summit County Case Study, Denver, Colorado.

Colorado Ski Country U.S.A., 1982b, The Contribution of Skiing to the Colorado Economy, Grand County Case Study, Denver, Colorado.

Colorado Ski Country U.S.A., 1982c, The Contribution of Skiing to the Colorado Economy, Eagle County Case Study, Denver, Colorado.

Colorado Ski Country U.S.A., 1984, Skier Visits: Three Season Comparison. Colorado Ski Country U.S.A., Denver, Colorado.

Cope, O. B., 1975, Colorado Game Research Review, 1972-1974. Publication DOW-RR-G72-74, Colorado Div. Wildlife State, Dept. of Natural Resources, Denver, Colorado.

Costello, J., 1985, Landscape Architect, U. S. Forest Service, Routt District, personal communication with Craig Johnson, BIO/WEST, Inc., Sept. 4, 1985.

Cowardin, L. M., V. Carter, F. Golet, and E. LaRoe, 1979, Classification of Wetlands and Deepwater Habitats of the United States. Biological Services Program, FWS/OBS-79/31, USDI Fish and Wildlife Service, Washington, DC.

Dahlem, E. A., 1979, The Mahogany Creek Watershed--With and Without Grazing. In Proc. Forum - Grazing and Riparian/Stream Ecosystems, Trout Unlimited, Inc.

Donner, H. F., 1949, Geology of the McCoy Area, Eagle and Routt Counties, Colorado. Geol. Soc. America Bull., V. 60, No. 8, pp 1215-1247.

Einstein, H. A., 1950, The Bed Load Function for Sediment Transportation in Open Channel Flows. U. S. Dept. of Agriculture, Soil Conservation Service, Technical Bulletin No. 1026.

Farmer, R., 1979, A Cultural Resource Inventory in the Routt National Forest. Commonwealth Associates, Jackson, Michigan.

Fitting, J. E., 1978, A Class II Cultural Resource Inventory of the Middle Park Planning Unit, Craig District, Colorado. Commonwealth Associates, Jackson, Michigan.

Freddy, D., 1986, Wildlife Researcher, Colorado Div. of Wildlife. Personal communication with Roy Hugie, BIO/WEST, Inc.

Gilbert, P. F., O. C. Wallmo, and R. B. Gill, 1970, Effect of Snow Depth on Mule Deer in Middle Park, Colorado. J. Wildlife Manage. 32:15-23.

Gill, R. B., 1969, Middle Park Deer Study--Population Density and Structure. Colo. Div. Game, Fish and Parks, Game Res. Div. Fed. Aid Project W-38-R-23, Game Res. Report, July, Part 1, pp. 105-122.

Gill, R. B., 1970, Middle Park Deer Study--Productivity and Mortality. Colo. Div. Game, Fish and Parks, Game Res. Div. Fed. Aid Project W-38-R-24, Game Res. Report, July, Part 3, pp. 337-354.

Gill, R. B., 1971, Middle Park Deer Study--Population Density and Structure. Colo. Div. Game, Fish and Parks, Game Res. Div. Fed. Aid Project W-38-R-25, Game Res. Report, July, Part 2, pp. 169-188.

Grah, O. J., and E. Neese, 1986, Rare Plant Survey of the Muddy Creek Reservoir Site. Unpublished document, BIO/WEST, Inc., Logan, Utah.

Gunderson, D. R., 1968, Floodplain Use Related to Stream Morphology and Fish Populations. J. Wildlife Management, 32:507-514.

Harr, D., 1986, Supervisory Range Conservationist, Kremmling Resource Area, Kremmling, Colorado. Personal communication with Oliver Grah, BIO/WEST, Inc.

Hays, R. L., and J. E. Heasley, 1985, A Users Manual for MICRO-HSI Habitat Suitability Index Modeling Software for Microcomputers, Version 1.2. Western Energy and Land Use Team, USDI, Fish and Wildlife Service, Fort Collins, Colorado.

Hem, J. D., 1985, Study and Interpretation of the Chemical Characteristics of Natural Water, 3rd Edition. U. S. Geological Survey Water-Supply Paper 2254, 263 pp.

Hobbs, N. T., D. L. Baker, J. E. Ellis, and D. M. Swift, 1981, Composition and Quality of Elk Winter Diets in Colorado. J. Wildlife Manage. 45:156-171.

Hoover, R. L., and D. L. Wills, 1984, Managing Forested Lands for Wildlife. Colorado Div. of Wildlife in cooperation with USDA Forest Service, Rocky Mountain Region, Denver, Colorado, 459 pp.

Hugie, R. D., 1973, A Winter Study of Deer Mobility in West-Central Maine. M. S. Thesis, Univ. of Maine, 78 pp.

International Engineering Company, 1983, Azure Project, Definite Project Report. Prepared for Municipal Subdistrict, Northern Colorado Water Conservancy District, Loveland, Colorado, September.

Iorns, W. V., C. H. Hembree and G. L. Oakland, 1965, Water Resources of the Upper Colorado River Basin--Technical Report. U. S. Geol. Survey Prof. Paper 441, 370 pp.

Izett, G. L., and W. A. Cobban, 1986, U. S. Geological Survey, Denver, Colorado. Personal communication with P. Nickens, BIO/WEST, Inc.

Izett, G. L., W. A. Cobban and J. R. Gill, 1971, The Pierre Shale near Kremmling, Colorado, and Its Correlation to the East and West. U. S. Geological Survey Professional Paper 684-A, pp. A1-A19.

Izett, G. L., and C. S. V. Barclay, 1973, Geologic Map of the Kremmling Quadrangle, Grand County, Colorado. U. S. Geological Survey Quadrangle Map GQ-115, 1:62,500.

Izett, G. L., 1968, Geology of the Hot Sulphur Springs Quadrangle, Grand County Colorado. U. S. Geological Survey Professional Paper 586, 79 pp.

Jaske, J. T., and J. B. Goebel, 1967, Effects of Dam Construction on Temperature of the Columbia River. JAWWA, Vol. 59(8), pp 935-942.

Johnson, A. M., 1977, Preliminary Cultural Resource Survey, Horse Creek, Yampa District, Routt National Forest. Colorado Historical Society and USDA Forest Service, Denver, Colorado.

Johnson, C., and O. J. Grah, 1986, Recreation Site Feasibility Study for the Proposed Rock Creek Reservoir Site. Unpublished report, BIO/WEST, Inc., Logan, Utah.

Jones, K. T., 1979, Archaeological Investigations in the Kremmling Area, Grand County, Colorado. Reports of the Laboratory of Public Archaeology No. 28, Colorado State University, Fort Collins, Colorado.

Kauffman, J. B., and W. C. Krueger, 1984, Livestock Impacts on Riparian Ecosystems and Streamside Management Implications. . .a Review. J. Range Management, 37:430-437.

Kauffman, J. B., W. C. Krueger and M. Vavra, 1983, Impacts of Cattle on Streambanks in Northeastern Oregon. J. Range Management, 36:683-685.

Klesert, A. L., 1981, Seven Timber Sale Tracts, Routt National Forest. Centuries Research, Montrose, Colorado.

Kron, D. G., 1986, Paleontological Reconnaissance of the Muddy Creek Valley North of Kremmling, Grand County, Colorado. Final report to BIO/WEST, Inc., Logan, Utah.

Kung, P., 1986, Spring Raptor Survey. Report submitted to BIO/WEST, Inc., April 1986.

Kurt, S., 1974, Cultural Resource Inventory Report: Decker Creek Timber Sale. Report on file at the Routt National Forest, Yampa Ranger District, Yampa, Colorado.

Lane, E. W., 1957, A Study of the Shape of Channels Formed by Natural Streams Flowing in Erodible Material. Missouri River Division Sediment Series No. 9, U. S. Army Engineer Division, Missouri River, Corps of Engineers, Omaha, Nebraska.

Leigh, Scott and Cleary/Fox Fire Community Planning and Development, 1985, Grand County Transit Development Program, 1986-1990. Technical Memorandum No. 1, prepared for Grand County, Hot Sulphur Springs, Colorado.

Lewis, W. M., J. F. Saunders, D. W. Crumpacker, and C. Brendecke, 1984, Eutrophication and Land Use, Lake Dillon, Colorado. Ecological Studies No. 46, Springer-Verlag, 202 pp.

Lischka, J. J., and K. Black, 1979, Final Report on a Cultural Resource Inventory and Testing Program of Archaeological Sites in the Right-of-Way of the Gore Pass-Windy Gap Transmission Line. Bureau of Anthropological Research, Dept. of Anthropology, University of Colorado, Boulder, Colorado.

Lyons, L. J., 1984, Field Test of Elk/Timber Coordination Gudelines. Res. Paper INT-325, U.S. Dept. of Agri., For. Serv. Intermt. For. and Range Exp. Sta., Ogden, Utah, 10 pp.

McConnell, W. J., E. P. Bergesen and K. L. Williamson, 1982, Habitat Suitability Index Models: A Low Effort System for Planned Cool Water and Cold Water Reservoirs, FWS/OBS-82/10.3.

McCullough, B., 1986, Soil Scientist, USDA Soil Conservation Service, Denver, Colorado.

McKean, J. R., and K. C. Nobe, 1983, Sportsmen Expenditures for Hunting and Fishing in Colorado--1981. Colorado Water Resources Research Institute, Colorado State Univ., Fort Collins, Colorado.

McKean, J. R., and K. C. Nobe, 1984, Direct and Indirect Economic Effects of Hunting and Fishing in Colorado--1981. Colorado Water Resources Research Institute, Colorado State Univ., Fort Collins, Colorado.

Milchunas, D. G., M. I. Dyer, O. C. Wallmo and D. E. Johnson, 1978, In-vivo/in-vitro Relationships of Colorado Mule Deer Forages. Special Report No. 43, Colorado Div. of Wildlife, Denver, Colorado, 44 pp.

Mueller, D. K., D. C. Craft, R. L. George, P. L. Johnson and R. A. Roline, 1981, Guidelines for Studies of Potential Eutrophication. Water Quality Planning Technical Memorandum, U. S. Bureau of Reclamation, Unpublished, 33 pp. and Appendix.

Meyer-Peter, E., and R. Muller, 1948, Formulas for Bed Load Transport. Proc., 3rd Meeting of IAHR, Stockholm pp 39-64.

Michael W. West and Associates, Inc., 1986, Seismotectonic Hazard Evaluation, Rock Creek Project near Kremmling, Grand and Routt Counties, Colorado, for Morrison-Knudsen Engineers, Inc., Denver, Colorado, March.

Morrison-Knudsen Engineers, Inc., 1986, Report on Feasibility Investigations, Rock Creek Dam Project, for the Colorado River Water Conservation District, Glenwood Springs, Colorado, May.

Nickens and Associates, 1986, Cultural Resource Investigations for the Rock Creek Dam RCC Aggregate Project. Report prepared for Morrison-Knudsen Engineers, Denver, Colorado.

Nickens, P. R., 1986, Cultural Resources Baseline Report for the Colorado River Water Conservation District Proposed Rock Creek and Muddy Creek Alternative Dam Sites. Final report to BIO/WEST, Inc., Logan, Utah.

O'Kane, S., 1986, Botanist, Natural Areas Program, Colorado State Dept. of Natural Resources, Denver, Colorado.

Olsen, P. O., 1987, Regional Manager, Colorado Div. of Wildlife, Grand Junction, Colorado. Letter transmitted to Jerry Schmidt, Forest Supervisor, Routt National Forest, USFS, Steamboat Springs, Colorado.

Parker, K. L., C. T. Robbins, and T. A. Hanley, 1984, Energy Expenditures for Locomotion by Mule Deer and Elk. J. Wildlife Manage. 48:474-488.

Pekins, R. S., and R. D. Hugie, 1986, A Summary of the Habitat Evaluation Procedures (HEP) Analysis Performed in Conjunction with the Rock Creek/Muddy Creek Environmental Impact Statement. BIO/WEST, Inc., Technical Report, 24 pp.

Pemberton, E. L., 1976, Channel Changes in the Colorado River Below Glen Canyon Dam. Proceedings of the Federal Interagency Sedimentation Conference (3rd) at Denver, Colorado, March 22-25, pp. 5-61 - 5-73.

Platts, W. S., and F. J. Wagstaff, 1984, Riparian and Stream Enhancement Management and Research in the Rocky Mountains

Platts, W. S., and R. L. Nelson, 1985, Impacts of Rest Rotation Grazing on Streambanks in Forested Watersheds in Idaho. North Amer. J. Fisheries Biol. 5:547-556.

Price, P., and T. Arnow, 1974, Summary Appraisals of the Nation's Ground-Water Resources--Upper Colorado Region. U. S. Geol. Survey Prof. Paper 813-C, 40 pp.

Reed, S., 1986, Wildlife Biologist, Routt National Forest, USFS, Steamboat Springs, Colorado. Personal communication with R. S. Pekins, BIO/WEST, Inc.

Resource Consultants, Inc., 1987a, Rock Creek and Muddy Creek Hydrology Technical Report. Prepared for U. S. Forest Service, Routt National Forest, Steamboat Springs, Colorado.

Resource Consultants, Inc., 1987b, Application of the Channel Maintenance Flow Procedure to the Rock Creek Reservoir Project. Prepared for U. S. Forest Service, Routt National Forest, Steamboat Springs, Colorado.

Resource Consultants, Inc., 1987c, Dam-Break Analysis for the Proposed Rock Creek Dam. Prepared for U. S. Forest Service, Routt National Forest, Steamboat Springs, Colorado.

Resource Consultants, Inc., 1987d, Dam-Break Analysis for the Proposed Muddy Creek Dam. Prepared for U. S. Forest Service, Routt National Forest, Steamboat Springs, Colorado.

Resource Consultants, Inc., 1987e, Hydrology Technical Report, Rock Creek near McCoy, Colorado, Pre- and Post-Project Flows. Prepared for U. S. Forest Service, Routt National Forest, Steamboat Springs, Colorado.

Ruddy, B. C., 1986, Sediment Discharge in Muddy Creek near Kremmling, Colorado. Draft USGS Water Resources Investigation Report, Denver, Colorado.

Schnurr, P., 1985, Wildlife Biologist, Colorado Div. of Wildlife, Grand Junction, Colorado. Mimeographed material obtained by R. Hugie, BIO/WEST, Inc.

Schubert, K. C., 1981a, Final Report of a Class I Cultural Resource Inventory of the Kremmling Resource Area. Reports of the Laboratory of Public Archaeology No. 57, Colorado State University, Fort Collins, Colorado.

Schubert, K. C., 1981b, Final Report of a Class II Cultural Resource Inventory of the Kremmling Resource Area. Reports of the Laboratory of Public Archaeology No. 58, Colorado State University, Fort Collins, Colorado.

Schumm, S. A., 1977, The Fluvial System. John Wiley and Sons, Inc., New York.

Shields, W., 1985, A Status Report of the Blue River-Gore Pass Transmission Line Cultural Resource Inventory. Western Cultural Resources Management, Boulder, Colorado.

Snoeyink, V. L., and D. Jenkins, 1980, Water Chemistry. John Wiley & Sons, New York, 463 pp.

Spowart, R., 1986, Conservation Officer, Colorado Div. of Wildlife. Personal communication with Roy Hugie, BIO/WEST, Inc.

Strand, R. I., 1974, Sedimentation, Appendix H, in Design of Small Dams. U. S. Bureau of Reclamation, U. S. Government Printing Office, Washington, DC, pp. 767-796.

Sullivan, J. P., and J. D. Hartley, 1984a, Archaeological Survey for 18 Test Pit Locations for the Proposed Rock Creek Dam Site, Routt National Forest. Grand River Consultants Report 84067, Grand Junction, Colorado.

Sullivan, J. P., and J. D. Hartley, 1984b, Archaeological Monitor for Borrow Material Test Pit Excavations at the Proposed Rock Creek Dam Site, Routt National Forest. Grand River Consultants Report 84076, Grand Junction, Colorado.

Sullivan, J. P., 1985, Archaeological Survey of Morrison-Knudsen Engineers Muddy Creek Dam Site, Grand County, Colorado. Grand River Consultants Report 85041, Grand Junction, Colorado.

Sylvester, R. O., and R. W. Seabloom, 1964, Quality of Impounded Waters as Influenced by Site Preparation. Water Supply and Pollution Control, Dept. of Civil Engineer, Univ. of Washington, WPD-6-03-64.

Thomas, A. E., 1986, Riparian Protection/Enhancement in Idaho. Rangelands, 8:224-227.

Tierney, P., 1980, The 1980 Colorado Whitewater Boating Use and Economic Impact Study. Environmental Research and Technology, Inc., Denver, Colorado.

Tweto, O., 1976, Preliminary Geologic Map of Colorado, Misc. Field Studies Map MF-788. U. S. Geological Survey.

Tweto, O, 1979, Geologic Map of the Craig 1° x 2° Quadrangle, Northwestern Colorado. Miscellaneous Investigations Series Map I-972. U. S. Geological Survey, Denver, Colorado.

U. S. Army Corps of Engineers, 1986, Draft Metropolitan Denver Water Supply EIS, Omaha District, Omaha, Nebraska.

U. S. Dept. of Agriculture, Forest Service, 1974, U. S. Forest Service Agricultural Handbook No. 462, in National Forest Landscape Management, Vol. 2.

U. S. Dept. of Agriculture, Forest Service, 1979, Elk Wild and Scenic River, Final Environmental Impact Statement and Study Report, Routt National Forest, Steamboat Springs, Colorado.

U. S. Dept. of Agriculture, Forest Service, 1982, Final Environmental Impact Statement, Routt National Forest, Steamboat Springs, Colorado, Volumes 1-2.

U. S. Dept. of Agriculture, Forest Service, 1983, Land and Resource Management Plan, Routt National Forest. USDA Forest Service, Steamboat Springs, Colorado.

U. S. Dept. of Agriculture, Forest Service, 1986a, Procedure for Quantifying Channel Maintenance Flows, Chapter 30, Water Information Management System Handbook. (FSH 2509.17) Interim Directive No. 2, Washington, DC, September.

U. S. Dept. of Agriculture, Forest Service, 1986b, Unpublished Soil Pedon Descriptions. Routt National Forest, Steamboat Springs, Colorado.

U. S. Dept. of Agriculture, Soil Conservation Service, 1982, Important Farmland Inventory of Colorado. Denver, Colorado.

U. S. Dept. of Agriculture, Soil Conservation Service, 1983, Soil Survey of Grand County Area, Colorado. Denver, Colorado.

U. S. Dept. of Interior, Bureau of Land Management, 1980, Visual Resource Management Program. U. S. Government Printing Office.

U. S. Dept. of Interior, Bureau of Land Management, 1982, Recreation Area Management Plan, Upper Colorado River. Special Recreation Management Area, Glenwood Springs, Colorado.

U. S. Dept. of Interior, Bureau of Land Management, 1982, Recreation Area Management Plan, Upper Colorado River. Special Recreation Management Area, Glenwood Springs, Colorado.

U.S. Dept. of Interior, Bureau of Land Management, 1984a, Resource Management Plan/Environmental Impact Assessment, Kremmling Resource Area, Final, Vol. 3, Kremmling, Colorado.

U. S. Dept. of Interior, Bureau of Land Management, 1984, Proposed Resource Management Plan and Final Environmental Impact Statement for the Kremmling Resource Area (FES 84-7), Craig, Colorado.

U. S. Dept. of Interior, Bureau of Land Management, 1986, Upper Colorado River Update, Kremmling Colorado.

U. S. Dept. of Interior, Bureau of Reclamation, 1985, Draft Supplement to the Final Environmental Statement, Colorado-Big Thompson Windy Gap Projects Green Mountain Reservoir, Colorado, Water Marketing Program. Denver, Colorado, June.

U. S. Dept. of Interior, Bureau of Reclamation, 1986, Final Environmental Impact Statement, Stagecoach Reservoir Project, Colorado. Upper Colorado Region, Salt Lake City, Utah.

U. S. Dept. of Interior, Fish and Wildlife Service, 1980, Habitat Evaluation Procedures Workbook. HEP Group, Western Energy and Land Use Team, Fort Collins, Colorado.

U. S. Dept. of Interior, Geological Survey (USGS), 1977, Computation of Fluvial Sediment Discharge, Techniques of Water-Resources Investigations, Book 3, Chap. C3, 2nd Printing.

U. S. Dept. of Interior, Geological Survey (USGS), 1979, Reconnaissance Evaluation of Surface Water Quality in Eagle, Grand, Jackson, Pitkin, Routt, and Summit Counties, Colorado. L. J. Britton, Open-File Report 79-420, 285 pp.

U. S. Environmental Protection Agency, 1976, Quality Criteria for Water. U. S. Government Printing Office, Washington, DC. 256 pp.

Voegeli, P. T., Sr., 1965, Ground-Water Resources of North Park and Middle Park, Colorado--A Reconnaissance. U. S. Geol. Survey Water-Supply Paper 1809-G, pp G1-G54.

Vollenweider, R. A., 1968, Scientific Fundamentals of the Eutrophication of Lakes and Flowing Waters, with Particular Reference to Nitrogen and Phosphorus as Factors in Eutrophication, OCED Report, DAS/CSI 68.27.

Volt, M., 1986, District Conservationist, Grand and Summit Counties, USDA Soil Conservation Service, Kremmling, Colorado. Personal communication with Oliver Grah, BIO/WEST, Inc., Logan, Utah.

Ward, J. V., 1976a, Effects of Thermal Constancy and Seasonal Temperature Displacement on the Community Structure of Stream Macroinvertebrates. In Thermal Ecology II, ERDA Symposium Series (CONF-750425), pp 302-307.

Ward, J. V., 1976b, Effects of Flow Patterns Below Large Dams on Stream Benthos: A Review. In Instream Flow Needs Symposium, Vol. II, J. F. Orsborn and C. H. Allman, eds., American Fish Society, pp 235-253.

Ward-Williams, L., and M. S. Foster, n.d., Final Report of Cultural Resource Inventories, Routt National Forest, Steamboat Springs, Colorado, Fiscal Years 1975, 1976. Colorado State Historical Society and USDA Forest Service, Denver, Colorado.

Wentz, D. A., 1974, Effect of Mine Drainage on the Quality of Streams in Colorado, 1971-1972. Colorado Water Resources Circular No. 21, 250 pp.

Western Engineers, Inc., 1983, Preliminary Geologic Report for the Wolford Dam, for the Colorado River Water Conservation District, Glenwood Springs, Colorado, May.

Western Engineers, Inc., and R. J. Irish, 1984, Engineering Geologic Study and Construction Materials Investigation, Rock Creek Dam Site and Reservoir Area, Routt and Grand Counties, Colorado, for the Colorado River Water Conservation District, Glenwood Springs, Colorado, August.

Williams, G. P., 1978, Bank-Full Discharge of Rivers. Water Resources Research, Vol. 14, No. 6, pp 1141-1154.

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APPENDIX A--MONTHLY HYDROLOGIC DATA

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TABLE A.1

<u>Rock Creek Reservoir--Discharge Summary</u>

<u>Metro Denver Lease and West Slope Sales</u>

ROCK CREEK RESERVOIR OPERATIONS--DISCHARGE SUMMARY

WATER YEAR		INFLOW TO RES	¦----WEST SLOPE SALES----¦ FLOW BELOW RES	DIFF IN FLOW	PERCENT CHANGE	¦--METRO DENVER LEASE--¦ FLOW BELOW RES	DIFF IN FLOW	PERCENT CHANGE
		CFS	CFS	CFS	%	CFS	CFS	%
COL		1	2	3	4	5	6	7
	OCT	32	18	-15	-45	11	-21	-67
	NOV	19	40	22	117	53	35	187
	DEC	13	34	21	160	31	18	136
	JAN	11	32	21	193	23	12	108
	FEB	12	17	5	37	19	6	54
	MAR	13	17	4	31	14	0	4
1962	APR	176	102	-74	-42	97	-79	-45
	MAY	303	303	0	0	303	0	0
	JUN	151	151	0	0	146	-5	-3
	JUL	29	35	5	18	29	0	0
	AUG	11	26	15	147	11	0	0
	SEP	9	22	14	154	36	28	312
	OCT	11	18	7	61	37	26	227
	NOV	10	32	22	221	22	12	123
	DEC	10	31	21	214	13	3	31
	JAN	9	30	21	241	9	0	0
	FEB	11	15	5	41	13	2	16
	MAR	16	20	4	25	24	8	50
1963	APR	63	69	6	10	90	27	43
	MAY	90	20	-70	-78	10	-80	-89
	JUN	39	31	-8	-22	16	-23	-58
	JUL	10	26	15	147	40	30	282
	AUG	12	27	15	131	104	92	779
	SEP	9	23	14	151	59	50	551
	OCT	7	14	7	94	107	100	1354
	NOV	8	29	22	285	13	6	73
	DEC	5	27	21	386	5	0	0
	JAN	7	28	21	321	7	0	0
	FEB	6	11	5	72	6	0	-7
	MAR	9	13	4	43	11	1	14
1964	APR	22	28	6	27	25	3	13
	MAY	128	20	-108	-85	10	-118	-92
	JUN	85	24	-61	-72	10	-75	-89
	JUL	15	52	37	248	15	0	0
	AUG	12	27	15	130	29	17	139
	SEP	7	21	14	197	101	94	1364
	OCT	8	15	7	91	20	12	162
	NOV	8	30	22	278	18	10	123
	DEC	8	29	21	257	14	6	67
	JAN	8	29	21	275	13	5	70
	FEB	8	12	5	59	11	4	48
	MAR	8	12	4	50	12	4	52
1965	APR	24	30	6	25	25	1	5
	MAY	170	20	-150	-88	10	-160	-94
	JUN	185	185	0	0	84	-101	-55
	JUL	32	34	2	6	32	0	0

ROCK CREEK RESERVOIR OPERATIONS--DISCHARGE SUMMARY

WATER YEAR		INFLOW TO RES	¦----WEST SLOPE SALES----¦ FLOW BELOW RES	DIFF IN FLOW	PERCENT CHANGE	¦--METRO DENVER LEASE--¦ FLOW BELOW RES	DIFF IN FLOW	PERCENT CHANGE
		CFS	CFS	CFS	%	CFS	CFS	%
COL.		1	2	3	4	5	6	7
	AUG	18	33	15	87	18	0	0
	SEP	18	31	14	77	18	0	2
	OCT	15	22	7	46	52	37	250
	NOV	9	31	22	249	35	26	299
	DEC	9	30	21	241	26	18	202
	JAN	8	29	21	257	17	8	103
	FEB	8	12	5	59	14	6	84
	MAR	9	13	4	45	18	9	99
1966	APR	29	43	15	51	49	21	72
	MAY	70	20	-50	-72	10	-60	-86
	JUN	17	30	14	81	16	-1	-3
	JUL	9	24	15	182	9	0	0
	AUG	7	23	15	219	41	34	478
	SEP	10	23	14	140	28	18	188
	OCT	10	17	7	68	24	13	133
	NOV	7	29	22	298	8	0	6
	DEC	8	29	21	279	8	0	0
	JAN	8	30	21	250	8	0	0
	FEB	9	13	5	53	8	-1	-10
	MAR	11	15	4	37	14	3	28
1967	APR	50	56	6	12	79	29	58
	MAY	116	20	-96	-83	17	-99	-85
	JUN	80	24	-57	-71	10	-71	-88
	JUL	21	36	15	71	21	0	-2
	AUG	13	28	15	119	58	45	349
	SEP	11	25	14	124	52	41	375
	OCT	11	18	7	64	31	20	186
	NOV	11	32	22	206	20	9	84
	DEC	9	30	21	229	13	3	37
	JAN	9	30	21	240	14	6	65
	FEB	9	13	5	51	14	5	62
	MAR	9	13	4	45	10	1	7
1968	APR	25	31	6	23	25	-1	-3
	MAY	186	20	-167	-89	52	-134	-72
	JUN	189	164	-25	-13	182	-6	-3
	JUL	27	35	8	29	27	0	0
	AUG	18	33	15	88	18	0	0
	SEP	9	22	14	156	55	46	531
	OCT	10	17	7	69	38	28	286
	NOV	9	31	22	237	19	10	105
	DEC	8	29	21	279	12	4	54
	JAN	7	28	21	323	13	6	92
	FEB	6	11	5	72	7	1	16
	MAR	7	11	4	63	11	5	70
1969	APR	89	16	-73	-82	12	-77	-87
	MAY	140	95	-44	-32	112	-27	-19

ROCK CREEK RESERVOIR OPERATIONS--DISCHARGE SUMMARY

WATER YEAR		INFLOW TO RES	WEST SLOPE SALES FLOW BELOW RES	WEST SLOPE SALES DIFF IN FLOW	WEST SLOPE SALES PERCENT CHANGE	METRO DENVER LEASE FLOW BELOW RES	METRO DENVER LEASE DIFF IN FLOW	METRO DENVER LEASE PERCENT CHANGE
		CFS	CFS	CFS	%	CFS	CFS	%
COL.		1	2	3	4	5	6	7
	JUN	50	50	0	0	49	-2	-3
	JUL	18	33	15	86	18	0	0
	AUG	11	27	15	138	65	53	477
	SEP	11	25	14	121	59	48	428
	OCT	15	21	7	47	50	35	243
	NOV	11	33	22	202	22	11	105
	DEC	9	30	21	233	22	13	147
	JAN	7	28	21	292	20	13	178
	FEB	6	11	5	74	13	7	118
	MAR	5	9	4	82	13	8	164
1970	APR	69	75	6	9	78	9	13
	MAY	297	169	-128	-43	95	-202	-68
	JUN	141	141	0	0	137	-5	-3
	JUL	24	36	12	48	24	0	0
	AUG	11	27	15	136	23	12	104
	SEP	12	25	14	115	70	58	492
	OCT	14	20	7	51	43	30	219
	NOV	10	32	22	218	37	27	265
	DEC	9	30	21	242	25	16	187
	JAN	8	29	21	274	22	14	182
	FEB	8	12	5	57	20	12	152
	MAR	13	17	4	31	20	7	54
1971	APR	66	16	-50	-76	10	-56	-85
	MAY	206	135	-71	-34	83	-123	-60
	JUN	183	183	0	0	177	-6	-3
	JUL	31	34	4	12	31	0	0
	AUG	14	29	15	111	14	0	0
	SEP	14	28	14	97	35	21	149
	OCT	12	19	7	56	43	31	251
	NOV	7	29	22	294	21	13	176
	DEC	6	27	21	370	15	10	168
	JAN	6	27	21	348	16	10	164
	FEB	6	11	5	70	13	6	96
	MAR	16	20	4	26	31	16	103
1972	APR	61	67	6	10	61	0	1
	MAY	154	38	-116	-76	44	-110	-72
	JUN	111	111	0	0	107	-4	-3
	JUL	15	31	15	101	15	0	0
	AUG	9	24	15	178	51	43	491
	SEP	13	26	14	108	61	48	380
	OCT	16	23	7	42	41	25	153
	NOV	11	33	22	195	19	8	74
	DEC	7	28	21	296	14	7	94
	JAN	7	28	21	318	12	5	81
	FEB	6	11	5	74	9	3	52
	MAR	6	10	4	72	7	1	20

13-Mar-87

ROCK CREEK RESERVOIR OPERATIONS--DISCHARGE SUMMARY

WATER YEAR		INFLOW TO RES	WEST SLOPE SALES FLOW BELOW RES	WEST SLOPE SALES DIFF IN FLOW	WEST SLOPE SALES PERCENT CHANGE	METRO DENVER LEASE FLOW BELOW RES	METRO DENVER LEASE DIFF IN FLOW	METRO DENVER LEASE PERCENT CHANGE
		CFS	CFS	CFS	%	CFS	CFS	%
COL		1	2	3	4	5	6	7
1973	APR	85	91	6	7	88	3	3
	MAY	257	128	-128	-50	110	-147	-57
	JUN	139	139	0	0	134	-4	-3
	JUL	29	34	5	17	29	0	0
	AUG	13	28	15	122	14	1	9
	SEP	8	21	14	174	38	30	389
	OCT	8	15	7	84	21	13	157
	NOV	9	31	22	249	20	11	129
	DEC	7	28	21	303	16	9	133
	JAN	7	29	21	285	17	10	132
	FEB	8	12	5	58	11	3	45
	MAR	10	14	4	40	21	11	111
1974	APR	95	101	6	6	97	2	2
	MAY	221	103	-118	-53	125	-96	-44
	JUN	98	98	0	0	95	-3	-3
	JUL	26	35	10	37	26	0	0
	AUG	14	30	15	110	33	19	138
	SEP	15	29	14	91	43	28	188
	OCT	10	17	7	69	32	21	214
	NOV	9	31	22	233	18	9	92
	DEC	6	27	21	333	12	6	95
	JAN	4	25	21	556	9	5	133
	FEB	4	9	5	109	7	3	69
	MAR	5	9	4	89	8	4	82
1975	APR	10	16	6	62	14	4	41
	MAY	155	32	-122	-79	54	-101	-65
	JUN	206	206	0	0	199	-7	-3
	JUL	30	34	4	12	30	0	0
	AUG	10	26	15	149	39	29	275
	SEP	8	22	14	161	57	48	573
	OCT	8	15	7	89	27	19	245
	NOV	7	29	22	312	13	6	90
	DEC	7	28	21	323	11	4	62
	JAN	9	30	21	238	14	5	59
	FEB	9	14	5	49	12	3	33
	MAR	7	11	4	59	9	2	33
1976	APR	149	155	6	4	147	-2	-1
	MAY	192	75	-117	-61	70	-121	-63
	JUN	86	86	0	0	83	-3	-3
	JUL	16	31	15	97	16	0	0
	AUG	8	24	15	189	41	33	398
	SEP	7	21	14	182	61	54	717
	OCT	7	14	7	99	44	37	536
	NOV	6	28	22	382	15	9	159
	DEC	9	30	21	247	9	1	8
	JAN	6	27	21	355	6	0	3

ROCK CREEK RESERVOIR OPERATIONS--DISCHARGE SUMMARY

WATER YEAR		INFLOW TO RES	WEST SLOPE SALES: FLOW BELOW RES	WEST SLOPE SALES: DIFF IN FLOW	WEST SLOPE SALES: PERCENT CHANGE	METRO DENVER LEASE: FLOW BELOW RES	METRO DENVER LEASE: DIFF IN FLOW	METRO DENVER LEASE: PERCENT CHANGE
		CFS	CFS	CFS	%	CFS	CFS	%
COL.		1	2	3	4	5	6	7
	FEB	6	10	5	81	6	1	14
	MAR	7	11	4	57	10	3	43
1977	APR	27	33	6	22	33	6	23
	MAY	50	60	10	20	50	0	0
	JUN	13	27	14	104	43	30	231
	JUL	11	26	15	142	126	115	1058
	AUG	11	50	39	362	336	325	2997
	SEP	8	54	46	569	56	48	590
	OCT	11	39	28	254	63	52	469
	NOV	14	50	36	252	34	19	136
	DEC	11	45	33	296	36	25	218
	JAN	8	38	30	365	27	19	229
	FEB	9	18	9	105	17	9	100
	MAR	11	17	7	61	20	9	83
1978	APR	32	48	16	49	40	8	23
	MAY	134	20	-114	-85	10	-124	-93
	JUN	180	24	-156	-87	10	-170	-95
	JUL	27	35	9	32	20	-7	-26
	AUG	8	24	15	185	73	64	770
	SEP	6	20	14	223	43	37	608
	OCT	8	15	7	90	29	21	279
	NOV	8	30	22	260	11	5	65
	DEC	8	29	21	254	15	7	84
	JAN	8	29	21	254	20	12	139
	FEB	8	13	5	54	16	8	96
	MAR	8	12	4	49	21	12	147
1979	APR	129	135	6	5	130	1	1
	MAY	228	20	-209	-91	10	-218	-96
	JUN	162	107	-55	-34	10	-152	-94
	JUL	27	35	7	27	19	-8	-29
	AUG	12	27	15	132	12	0	0
	SEP	6	20	14	230	32	26	444
	OCT	5	12	7	133	25	20	378
	NOV	5	27	22	417	20	15	283
	DEC	5	26	21	413	13	8	156
	JAN	6	27	21	346	22	16	267
	FEB	6	11	5	74	16	10	169
	MAR	7	11	4	60	18	11	161
1980	APR	32	38	6	19	36	4	13
	MAY	218	98	-120	-55	10	-208	-95
	JUN	108	108	0	0	10	-99	-91
	JUL	19	34	15	83	19	0	0
	AUG	8	23	15	195	36	28	359
	SEP	8	21	14	179	71	64	838
	OCT	10	17	7	70	31	21	219
	NOV	7	29	22	308	15	8	111

ROCK CREEK RESERVOIR OPERATIONS--DISCHARGE SUMMARY

WATER YEAR		INFLOW TO RES	WEST SLOPE SALES: FLOW BELOW RES	WEST SLOPE SALES: DIFF IN FLOW	WEST SLOPE SALES: PERCENT CHANGE	METRO DENVER LEASE: FLOW BELOW RES	METRO DENVER LEASE: DIFF IN FLOW	METRO DENVER LEASE: PERCENT CHANGE
		CFS	CFS	CFS	%	CFS	CFS	%
COL.		1	2	3	4	5	6	7
	DEC	7	28	21	294	14	7	93
	JAN	8	29	21	259	8	0	0
	FEB	8	13	5	54	8	-1	-8
	MAR	10	15	4	39	12	1	12
1981	APR	49	55	6	12	83	35	72
	MAY	112	20	-92	-82	21	-91	-81
	JUN	77	40	-38	-49	10	-68	-87
	JUL	21	36	15	75	27	7	33
	AUG	12	28	15	125	244	232	1867
	SEP	10	24	14	130	54	43	412
	OCT	15	22	7	47	30	15	102
	NOV	10	32	22	222	11	1	12
	DEC	7	28	21	287	7	0	0
	JAN	6	27	21	376	9	4	67
	FEB	7	11	5	67	7	1	10
	MAR	8	12	4	52	15	7	90
1982	APR	28	34	6	21	53	25	88
	MAY	234	106	-128	-55	10	-224	-96
	JUN	95	95	0	0	10	-85	-90
	JUL	13	28	15	120	13	0	0
	AUG	6	22	15	239	6	0	0
	SEP	9	23	14	153	14	5	53
	AVG	37	37	0	0	37	0	0
	MIN	4	9	-209	-91	5	-224	-96
	MAX	303	303	46	569	336	325	2997

TABLE A.2

Blue River below Green Mountain Reservoir with

Rock or Muddy Creek Reservoir Operations

Metro Denver Lease and West Slope Sales

Summary Table

Rock/Muddy Creek Reservoir Analysis -- Blue River Below Green Mo

				¦--- West Slope Sales --¦			--Metro Denver Lease--¦		
Water Year	Month	Historic Blue R. Flows (cfs)	Simulate Base Flows (cfs)	Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change	Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change
		1	2	3	4	5	6	7	8
	OCT	435	280	276	-4	-1.51	280	0	0.00
	NOV	332	325	313	-12	-3.69	325	0	0.00
	DEC	423	340	328	-12	-3.42	340	0	0.00
	JAN	456	340	328	-12	-3.42	340	0	0.00
	FEB	559	340	338	-2	-0.56	340	0	0.00
	MAR	864	311	309	-2	-0.61	311	0	-0.05
1962	APR	802	350	351	2	0.49	355	5	1.44
	MAY	1375	89	77	-11	-12.91	84	-5	-5.32
	JUN	599	281	269	-13	-4.53	279	-3	-0.96
	JUL	845	388	379	-9	-2.36	391	3	0.67
	AUG	540	361	364	3	0.80	376	15	4.05
	SEPT	474	235	236	2	0.72	246	12	5.01
	OCT	1258	366	363	-3	-0.71	367	2	0.44
	NOV	800	350	332	-17	-4.92	344	-5	-1.49
	DEC	468	367	350	-17	-4.58	362	-5	-1.42
	JAN	200	367	350	-17	-4.58	362	-5	-1.42
	FEB	118	183	182	-1	-0.36	184	1	0.69
	MAR	101	137	136	0	-0.19	138	1	1.07
1963	APR	140	193	197	4	2.10	200	7	3.84
	MAY	93	60	53	-7	-11.21	60	0	0.00
	JUN	85	60	50	-10	-16.78	60	0	0.00
	JUL	327	316	304	-12	-3.73	316	0	0.00
	AUG	351	435	438	3	0.66	402	-34	-7.70
	SEPT	396	273	275	2	0.62	278	5	1.66
	OCT	360	426	423	-3	-0.69	336	-90	-21.19
	NOV	187	298	281	-18	-5.99	293	-6	-1.97
	DEC	124	302	284	-17	-5.79	296	-6	-1.94
	JAN	122	302	284	-17	-5.79	296	-6	-1.94
	FEB	142	172	172	-1	-0.38	174	1	0.73
	MAR	170	145	144	0	-0.18	146	1	1.01
1964	APR	162	147	151	4	2.75	155	7	5.02
	MAY	82	60	53	-7	-11.21	60	0	0.00
	JUN	80	60	50	-10	-16.78	60	0	0.00
	JUL	209	60	48	-12	-19.60	60	0	0.00
	AUG	270	152	154	3	1.90	166	15	9.66
	SEPT	500	274	276	2	0.62	197	-77	-28.02
	OCT	471	405	382	-23	-5.62	386	-19	-4.58
	NOV	216	288	270	-18	-6.16	282	-6	-1.99
	DEC	249	286	269	-17	-6.10	281	-6	-2.04
	JAN	247	286	269	-17	-6.10	281	-6	-2.04
	FEB	235	286	279	-8	-2.74	281	-6	-2.07
	MAR	246	292	288	-4	-1.32	290	-2	-0.72
1965	APR	401	215	209	-6	-2.88	212	-3	-1.33
	MAY	73	60	53	-7	-11.21	60	0	0.00
	JUN	72	243	228	-15	-6.35	238	-5	-2.21
	JUL	746	441	431	-10	-2.30	442	2	0.37
	AUG	869	498	486	-12	-2.36	498	0	0.00
	SEPT	412	301	303	2	0.56	313	12	3.90

Rock/Muddy Creek Reservoir Analysis -- Blue River Below Green Mo

Water Year	Month	Historic Blue R. Flows (cfs)	Simulate Base Flows (cfs)	West Slope Sales: Simulated Project Flows (cfs)	West Slope Sales: Change In Flows (cfs)	West Slope Sales: Percent Change	Metro Denver Lease: Simulated Project Flows (cfs)	Metro Denver Lease: Change In Flows (cfs)	Metro Denver Lease: Percent Change
		1	2	3	4	5	6	7	8
	OCT	371	304	303	-1	-0.48	307	3	0.91
	NOV	372	372	358	-15	-3.95	370	-3	-0.72
	DEC	484	387	373	-14	-3.71	385	-3	-0.71
	JAN	427	387	373	-14	-3.71	385	-3	-0.71
	FEB	429	213	213	0	0.03	215	2	0.93
	MAR	437	171	170	0	-0.16	172	1	0.86
1966	APR	251	174	178	4	2.33	182	7	4.24
	MAY	58	60	53	-7	-11.21	60	0	0.00
	JUN	76	60	50	-10	-16.78	60	0	0.00
	JUL	336	75	64	-12	-15.62	75	0	0.00
	AUG	498	311	314	3	0.92	326	15	4.70
	SEPT	644	649	637	-12	-1.81	648	-2	-0.26
	OCT	423	381	378	-3	-0.81	382	1	0.30
	NOV	234	252	234	-18	-7.10	246	-6	-2.34
	DEC	244	260	242	-17	-6.73	254	-6	-2.26
	JAN	291	260	242	-17	-6.73	254	-6	-2.26
	FEB	285	167	166	-1	-0.39	168	1	0.76
	MAR	282	171	171	0	-0.16	173	1	0.86
1967	APR	360	215	219	4	1.88	223	7	3.43
	MAY	76	74	68	-7	-9.05	74	0	0.00
	JUN	56	60	50	-10	-16.78	60	0	0.00
	JUL	237	60	48	-12	-19.60	60	0	0.00
	AUG	544	306	309	3	0.94	321	15	4.78
	SEPT	457	225	226	2	0.75	236	12	5.24
	OCT	350	269	244	-25	-9.13	249	-20	-7.56
	NOV	298	346	325	-21	-6.09	337	-9	-2.62
	DEC	253	355	339	-16	-4.60	350	-5	-1.33
	JAN	246	355	339	-16	-4.60	350	-5	-1.33
	FEB	241	184	184	-1	-0.36	186	1	0.68
	MAR	258	127	126	0	-0.21	128	1	1.16
1968	APR	528	103	107	4	3.95	110	7	7.21
	MAY	155	60	53	-7	-11.21	60	0	0.00
	JUN	143	60	50	-10	-16.78	60	0	0.00
	JUL	457	60	48	-12	-19.60	60	0	0.00
	AUG	546	184	151	-33	-17.71	163	-21	-11.32
	SEPT	478	274	276	2	0.62	286	12	4.29
	OCT	430	310	309	-1	-0.47	313	3	0.89
	NOV	295	372	357	-15	-3.95	369	-3	-0.72
	DEC	307	379	364	-14	-3.76	376	-3	-0.69
	JAN	301	379	364	-14	-3.76	376	-3	-0.69
	FEB	298	379	374	-5	-1.22	376	-3	-0.71
	MAR	299	139	136	-3	-2.06	138	-1	-0.82
1969	APR	369	150	152	3	1.92	156	6	4.04
	MAY	567	60	53	-7	-11.21	60	0	0.00
	JUN	594	60	50	-10	-16.78	60	0	0.00
	JUL	936	157	136	-21	-13.18	148	-9	-5.69
	AUG	596	419	422	3	0.69	434	15	3.49
	SEPT	437	307	309	2	0.55	319	12	3.83

Rock/Muddy Creek Reservoir Analysis -- Blue River Below Green Mo

Water Year	Month	Historic Blue R. Flows (cfs)	Simulate Base Flows (cfs)	West Slope Sales: Simulated Project Flows (cfs)	West Slope Sales: Change In Flows (cfs)	West Slope Sales: Percent Change	Metro Denver Lease: Simulated Project Flows (cfs)	Metro Denver Lease: Change In Flows (cfs)	Metro Denver Lease: Percent Change
		1	2	3	4	5	6	7	8
	OCT	335	328	325	-3	-0.79	330	2	0.50
	NOV	370	362	345	-17	-4.76	357	-5	-1.44
	DEC	323	386	369	-17	-4.36	381	-5	-1.35
	JAN	317	386	369	-17	-4.36	381	-5	-1.35
	FEB	409	386	379	-7	-1.85	381	-5	-1.35
	MAR	463	251	248	-4	-1.40	249	-2	-0.71
1970	APR	416	264	249	-14	-5.41	253	-11	-4.15
	MAY	1145	154	116	-38	-24.88	122	-32	-20.51
	JUN	1530	154	112	-42	-27.07	122	-32	-20.52
	JUL	635	338	395	57	16.97	407	69	20.45
	AUG	651	194	180	-14	-7.14	192	-2	-1.09
	SEPT	461	250	239	-10	-4.03	250	0	0.00
	OCT	404	299	299	0	-0.16	303	4	1.31
	NOV	345	383	370	-13	-3.35	382	-1	-0.22
	DEC	358	396	384	-12	-3.14	395	-1	-0.21
	JAN	358	396	384	-12	-3.14	395	-1	-0.21
	FEB	448	396	393	-3	-0.67	395	-1	-0.18
	MAR	467	274	272	-2	-0.81	274	0	-0.18
1971	APR	570	282	283	1	0.48	286	5	1.67
	MAY	677	193	183	-10	-5.10	189	-3	-1.60
	JUN	801	193	179	-13	-6.80	190	-3	-1.57
	JUL	1243	360	352	-8	-2.27	364	4	0.99
	AUG	611	151	136	-15	-9.63	148	-3	-1.83
	SEPT	450	254	244	-10	-3.97	254	0	0.00
	OCT	416	306	306	0	-0.10	310	4	1.28
	NOV	341	380	367	-13	-3.34	379	-1	-0.18
	DEC	328	396	384	-12	-3.10	396	-1	-0.16
	JAN	327	396	384	-12	-3.10	396	-1	-0.16
	FEB	336	396	393	-3	-0.67	395	-1	-0.18
	MAR	440	225	222	-2	-0.99	224	0	-0.22
1972	APR	494	176	179	3	1.82	183	6	3.63
	MAY	450	60	53	-7	-11.21	60	0	0.00
	JUN	800	60	50	-10	-16.78	60	0	0.00
	JUL	584	255	237	-19	-7.29	248	-7	-2.68
	AUG	579	400	402	3	0.72	414	15	3.66
	SEPT	465	334	336	2	0.51	346	12	3.52
	OCT	368	304	302	-3	-0.85	306	2	0.53
	NOV	334	362	345	-17	-1.76	357	-5	-1.44
	DEC	294	379	362	-17	-4.44	374	-5	-1.37
	JAN	303	379	362	-17	-4.44	374	-5	-1.37
	FEB	302	379	372	-7	-1.88	374	-5	-1.38
	MAR	300	229	226	-4	-1.53	228	-2	-0.78
1973	APR	296	211	210	0	-0.07	214	3	1.52
	MAY	451	101	89	-12	-11.79	96	-5	-5.14
	JUN	700	101	86	-15	-15.10	96	-5	-5.15
	JUL	1260	403	394	-8	-2.03	406	4	0.89
	AUG	571	224	210	-14	-6.20	222	-2	-0.94
	SEPT	430	215	205	-10	-4.67	215	0	0.00

Rock/Muddy Creek Reservoir Analysis -- Blue River Below Green Mo

Water Year	Month	Historic Blue R. Flows (cfs)	Simulate Base Flows (cfs)	--- West Slope Sales -- Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change	--Metro Denver Lease-- Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change
		1	2	3	4	5	6	7	8
	OCT	480	289	289	0	-0.17	293	4	1.35
	NOV	453	382	369	-13	-3.37	381	-1	-0.22
	DEC	322	389	376	-12	-3.16	388	-1	-0.17
	JAN	305	389	376	-12	-3.16	388	-1	-0.17
	FEB	306	389	386	-3	-0.68	388	-1	-0.19
	MAR	450	274	272	-2	-0.81	274	0	-0.18
1974	APR	491	258	259	2	0.59	263	5	1.89
	MAY	730	173	161	-12	-6.91	167	-5	-3.02
	JUN	1007	196	183	-13	-6.68	193	-3	-1.54
	JUL	767	331	322	-8	-2.48	334	4	1.08
	AUG	618	165	166	1	0.46	177	13	7.59
	SEPT	638	204	194	-10	-4.94	204	0	0.00
	OCT	339	300	299	-1	-0.48	303	3	0.92
	NOV	262	381	366	-15	-3.90	378	-3	-0.75
	DEC	261	388	373	-15	-3.79	385	-3	-0.80
	JAN	260	388	373	-15	-3.79	385	-3	-0.80
	FEB	254	388	383	-5	-1.28	385	-3	-0.79
	MAR	250	214	211	-3	-1.34	212	-1	-0.53
1975	APR	482	185	185	1	0.28	189	4	2.18
	MAY	368	74	63	-11	-14.90	69	-4	-5.75
	JUN	275	73	59	-14	-19.43	69	-4	-5.72
	JUL	776	405	397	-8	-2.02	409	4	0.88
	AUG	671	246	232	-14	-5.72	243	-2	-0.93
	SEPT	532	244	246	2	0.69	256	12	4.81
	OCT	446	272	271	-1	-0.53	275	3	1.08
	NOV	264	374	359	-15	-3.93	371	-3	-0.72
	DEC	257	380	366	-14	-3.74	377	-3	-0.69
	JAN	260	380	366	-14	-3.74	377	-3	-0.69
	FEB	290	380	375	-5	-1.22	377	-3	-0.71
	MAR	407	147	144	-3	-1.95	146	-1	-0.77
1976	APR	331	159	162	3	1.81	165	6	3.92
	MAY	335	60	53	-7	-11.21	60	0	0.00
	JUN	520	60	50	-10	-16.78	60	0	0.00
	JUL	249	134	113	-21	-15.39	125	-9	-6.58
	AUG	421	371	374	3	0.77	386	15	3.95
	SEPT	573	284	286	2	0.60	296	12	4.14
	OCT	375	316	314	-3	-0.82	318	2	0.51
	NOV	321	362	345	-17	-4.76	357	-5	-1.44
	DEC	307	368	351	-17	-4.57	363	-5	-1.41
	JAN	287	368	351	-17	-4.57	363	-5	-1.41
	FEB	193	178	177	-1	-0.37	179	1	0.71
	MAR	151	141	140	0	-0.19	142	1	1.04
1977	APR	205	158	162	4	2.56	166	7	4.67
	MAY	59	95	97	2	2.16	104	9	9.23
	JUN	173	106	99	-7	-6.52	109	3	3.03
	JUL	564	418	422	4	1.00	319	-99	-23.64
	AUG	756	609	588	-21	-3.43	299	-310	-50.93
	SEPT	586	756	707	-50	-6.57	717	-40	-5.24

Rock/Muddy Creek Reservoir Analysis -- Blue River Below Green Mo

Water Year	Month	Historic Blue R. Flows (cfs)	Simulate Base Flows (cfs)	Simulated Project Flows (cfs)	West Slope Sales: Change In Flows (cfs)	West Slope Sales: Percent Change	Metro Denver Lease: Simulated Project Flows (cfs)	Metro Denver Lease: Change In Flows (cfs)	Metro Denver Lease: Percent Change
		1	2	3	4	5	6	7	8
	OCT	302	352	333	-19	-5.36	339	-13	-3.70
	NOV	147	182	166	-16	-8.54	183	1	0.55
	DEC	172	192	178	-15	-7.56	193	1	0.42
	JAN	223	172	161	-11	-6.47	174	2	0.95
	FEB	250	169	167	-3	-1.56	170	0	0.21
	MAR	187	160	158	-3	-1.59	144	-17	-10.45
1978	APR	76	149	148	-1	-0.44	142	-6	-4.29
	MAY	58	60	53	-7	-11.21	60	0	0.00
	JUN	58	60	50	-10	-16.78	60	0	0.00
	JUL	468	60	48	-12	-19.60	60	0	0.00
	AUG	197	401	404	3	0.72	416	15	3.77
	SEPT	516	394	384	-10	-2.56	428	34	8.62
	OCT	306	353	351	-2	-0.55	355	2	0.65
	NOV	283	306	290	-16	-5.18	302	-4	-1.26
	DEC	283	302	287	-16	-5.13	299	-4	-1.29
	JAN	285	302	287	-16	-5.13	299	-4	-1.29
	FEB	289	302	297	-6	-1.88	299	-4	-1.25
	MAR	260	256	253	-3	-1.18	255	-1	-0.51
1979	APR	167	262	262	0	0.14	266	4	1.41
	MAY	59	68	53	-14	-21.24	60	-8	-11.30
	JUN	113	180	166	-15	-8.09	176	-5	-2.51
	JUL	1246	344	336	-8	-2.38	348	4	1.04
	AUG	101	302	390	88	29.22	402	100	33.12
	SEPT	478	246	236	-10	-4.10	246	0	0.00
	OCT	391	276	267	-9	-3.29	271	-5	-1.77
	NOV	292	374	344	-30	-7.97	356	-18	-4.76
	DEC	292	372	343	-29	-7.88	355	-18	-4.76
	JAN	295	372	343	-29	-7.88	355	-18	-4.76
	FEB	312	372	353	-20	-5.26	355	-18	-4.74
	MAR	363	235	228	-7	-3.02	230	-5	-2.28
1980	APR	498	170	165	-5	-2.96	168	-2	-0.99
	MAY	744	86	69	-18	-20.59	75	-11	-12.81
	JUN	999	86	65	-21	-24.50	75	-11	-12.84
	JUL	629	392	383	-8	-2.09	395	4	0.91
	AUG	529	187	190	3	1.54	202	15	7.82
	SEPT	530	244	246	2	0.69	256	12	4.82
	OCT	349	356	353	-3	-0.78	357	1	0.41
	NOV	289	349	331	-17	-4.99	343	-5	-1.54
	DEC	288	346	329	-17	-4.86	341	-5	-1.50
	JAN	219	346	329	-17	-4.86	341	-5	-1.50
	FEB	151	169	169	-1	-0.39	171	1	0.74
	MAR	160	146	146	0	-0.18	148	1	1.00
1981	APR	253	274	278	4	1.48	281	7	2.70
	MAY	138	119	121	2	1.73	128	9	7.39
	JUN	54	76	69	-7	-9.07	79	3	4.21
	JUL	131	139	143	4	3.00	155	16	11.46
	AUG	451	601	604	3	0.48	384	-217	-36.10
	SEPT	366	440	442	2	0.38	452	12	2.67

Rock/Muddy Creek Reservoir Analysis -- Blue River Below Green Mo

Water Year	Month	Historic Blue R. Flows (cfs)	Simulate Base Flows (cfs)	West Slope Sales: Simulated Project Flows (cfs)	West Slope Sales: Change In Flows (cfs)	West Slope Sales: Percent Change	Metro Denver Lease: Simulated Project Flows (cfs)	Metro Denver Lease: Change In Flows (cfs)	Metro Denver Lease: Percent Change
		1	2	3	4	5	6	7	8
	OCT	209	252	253	1	0.46	257	6	2.20
	NOV	169	229	207	-23	-9.85	219	-11	-4.62
	DEC	167	240	216	-24	-9.86	228	-12	-5.02
	JAN	210	240	216	-24	-9.86	228	-12	-5.02
	FEB	218	240	226	-14	-5.83	228	-12	-5.03
	MAR	210	171	165	-5	-3.20	167	-4	-2.19
1982	APR	251	163	164	2	0.94	168	5	3.00
	MAY	68	60	53	-7	-11.21	60	0	0.00
	JUN	329	60	50	-10	-16.78	60	0	0.00
	JUL	410	143	112	-30	-21.22	124	-19	-12.98
	AUG	634	404	392	-12	-2.91	404	0	0.00
	SEPT	388	287	289	2	0.59	299	12	4.10

TABLE A.3

Rock Creek Reservoir Analysis--Colorado River at Kremmling Gage

Metro Denver Lease and West Slope Sales

Summary Table

Rock Creek Reservoir Analysis -- Colorado River At Kremmling Gage

Water Year	Month	Historic Kremmlin Flows (cfs)	Simulate Base Flows (cfs)	West Slope Sales: Simulated Project Flows (cfs)	West Slope Sales: Change In Flows (cfs)	West Slope Sales: Percent Change	Metro Denver Lease: Simulated Project Flows (cfs)	Metro Denver Lease: Change In Flows (cfs)	Metro Denver Lease: Percent Change
		1	2	3	4	5	6	7	8
	OCT	1005	849	844	-6	-0.69	849	0	0.00
	NOV	754	819	804	-15	-1.80	782	-36	-4.43
	DEC	842	794	780	-14	-1.80	776	-18	-2.25
	JAN	909	816	801	-14	-1.75	804	-12	-1.46
	FEB	1025	822	818	-4	-0.45	813	-8	-1.03
	MAR	1394	842	838	-4	-0.42	841	-1	-0.08
1962	APR	3297	2491	2491	0	0.00	2496	5	0.20
	MAY	4232	2346	2333	-13	-0.56	2341	-5	-0.20
	JUN	2472	1561	1547	-14	-0.93	1559	-3	-0.17
	JUL	2304	1848	1837	-11	-0.58	1850	3	0.11
	AUG	1011	826	827	1	0.15	840	15	1.77
	SEPT	762	575	575	0	0.00	558	-17	-2.95
	OCT	1413	572	567	-4	-0.77	548	-24	-4.21
	NOV	1017	591	571	-20	-3.38	573	-18	-3.07
	DEC	669	572	553	-19	-3.38	564	-8	-1.45
	JAN	522	688	668	-19	-2.83	683	-5	-0.76
	FEB	503	573	570	-2	-0.43	571	-2	-0.31
	MAR	564	616	614	-2	-0.31	609	-7	-1.08
1963	APR	613	725	728	2	0.32	703	-23	-3.11
	MAY	695	464	455	-8	-1.81	464	0	0.00
	JUN	466	441	430	-12	-2.67	441	0	0.00
	JUL	539	637	624	-13	-2.11	607	-30	-4.65
	AUG	630	954	955	1	0.13	878	-76	-7.99
	SEPT	757	698	698	0	0.00	658	-40	-5.73
	OCT	641	744	740	-5	-0.61	560	-184	-24.69
	NOV	442	521	501	-20	-3.93	510	-12	-2.26
	DEC	277	453	433	-20	-4.44	447	-6	-1.29
	JAN	278	456	436	-20	-4.42	450	-6	-1.28
	FEB	305	334	332	-3	-0.80	335	1	0.27
	MAR	336	313	311	-2	-0.61	314	0	0.05
1964	APR	536	528	531	2	0.45	532	4	0.73
	MAY	1032	594	586	-8	-1.41	594	0	0.00
	JUN	765	531	519	-12	-2.22	531	0	0.00
	JUL	565	415	401	-13	-3.23	415	0	0.00
	AUG	819	622	623	1	0.20	620	-2	-0.31
	SEPT	889	728	728	0	0.00	597	-131	-17.94
	OCT	654	642	638	-5	-0.74	631	-11	-1.75
	NOV	399	490	469	-21	-4.21	474	-16	-3.26
	DEC	411	458	438	-20	-4.39	447	-11	-2.48
	JAN	416	465	444	-20	-4.33	453	-11	-2.42
	FEB	390	450	441	-10	-2.11	440	-11	-2.36
	MAR	388	442	437	-5	-1.21	436	-6	-1.40
1965	APR	967	785	777	-8	-1.01	780	-5	-0.62
	MAY	1647	1035	1027	-8	-0.81	1035	0	0.00
	JUN	1875	1447	1430	-17	-1.18	1442	-5	-0.37
	JUL	1558	916	904	-12	-1.29	917	2	0.18
	AUG	1485	1106	1093	-13	-1.21	1106	0	0.00
	SEPT	770	656	656	0	0.00	667	11	1.64

Rock Creek Reservoir Analysis -- Colorado River At Kremmling Gage

					--- West Slope Sales --			--Metro Denver Lease--	
Water Year	Month	Historic Kremmlin Flows (cfs)	Simulate Base Flows (cfs)	Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change	Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change
		1	2	3	4	5	6	7	8
	OCT	762	766	762	-3	-0.41	731	-34	-4.50
	NOV	837	886	868	-17	-1.97	856	-30	-3.38
	DEC	904	841	824	-17	-2.01	821	-20	-2.42
	JAN	846	822	805	-17	-2.05	811	-11	-1.34
	FEB	853	653	651	-2	-0.30	647	-6	-0.94
	MAR	956	707	706	-2	-0.27	700	-7	-1.06
1966	APR	617	575	578	2	0.41	565	-10	-1.81
	MAY	720	382	373	-8	-2.19	382	0	0.00
	JUN	379	363	351	-12	-3.24	363	0	0.00
	JUL	795	539	525	-13	-2.49	539	0	0.00
	AUG	787	682	683	1	0.18	663	-19	-2.81
	SEPT	843	926	926	0	0.00	919	-7	-0.80
	OCT	631	615	610	-5	-0.74	602	-12	-1.98
	NOV	432	450	430	-20	-4.55	444	-6	-1.42
	DEC	381	395	375	-20	-5.10	389	-6	-1.48
	JAN	420	388	368	-20	-5.19	382	-6	-1.51
	FEB	448	329	327	-2	-0.75	330	1	0.38
	MAR	589	484	482	-2	-0.40	482	-2	-0.34
1967	APR	838	756	758	2	0.31	732	-24	-3.20
	MAY	863	481	472	-8	-1.74	473	-7	-1.52
	JUN	1048	453	441	-12	-2.60	453	0	0.00
	JUL	849	552	539	-13	-2.43	552	0	0.00
	AUG	862	777	779	1	0.16	747	-31	-3.95
	SEPT	755	697	697	0	0.00	666	-31	-4.48
	OCT	604	631	624	-6	-1.01	610	-21	-3.28
	NOV	558	623	599	-24	-3.85	604	-19	-2.99
	DEC	518	626	607	-19	-3.04	618	-8	-1.30
	JAN	534	653	634	-19	-2.91	643	-10	-1.59
	FEB	552	508	506	-2	-0.45	503	-6	-1.10
	MAR	546	416	414	-2	-0.46	417	1	0.20
1968	APR	938	512	514	2	0.46	519	7	1.44
	MAY	951	812	804	-8	-1.03	812	0	0.00
	JUN	1314	633	621	-12	-1.86	633	0	0.00
	JUL	922	525	512	-13	-2.55	525	0	0.00
	AUG	1049	679	645	-34	-5.04	658	-21	-3.07
	SEPT	804	692	692	0	0.00	655	-36	-5.25
	OCT	748	681	681	-3	-0.43	658	-26	-3.76
	NOV	628	724	707	-17	-2.39	711	-13	-1.76
	DEC	593	671	654	-17	-2.52	665	-7	-0.99
	JAN	586	674	657	-17	-2.51	665	-9	-1.30
	FEB	580	663	657	-6	-0.94	659	-5	-0.68
	MAR	584	434	429	-4	-1.00	428	-6	-1.27
1969	APR	943	729	730	1	0.16	732	4	0.51
	MAY	1176	581	573	-8	-1.44	581	0	0.00
	JUN	1961	828	816	-12	-1.42	828	0	0.00
	JUL	1545	671	649	-22	-3.33	662	-9	-1.33
	AUG	883	806	807	1	0.15	767	-39	-4.80
	SEPT	733	698	698	0	0.00	660	-38	-5.49

Rock Creek Reservoir Analysis -- Colorado River At Kremmling Gage

Water Year	Month	Historic Kremmlin Flows (cfs)	Simulate Base Flows (cfs)	¦--- West Slope Sales --¦ Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change	¦--Metro Denver Lease--¦ Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change
		1	2	3	4	5	6	7	8
	OCT	732	795	791	-4	-0.55	761	-34	-4.27
	NOV	736	751	731	-20	-2.64	733	-17	-2.28
	DEC	745	833	813	-19	-2.34	814	-19	-2.23
	JAN	627	721	701	-19	-2.70	703	-18	-2.50
	FEB	695	689	680	-9	-1.30	675	-14	-2.01
	MAR	778	582	577	-5	-0.89	572	-10	-1.70
1970	APR	1036	906	890	-16	-1.76	884	-23	-2.50
	MAY	4014	2424	2384	-40	-1.65	2392	-32	-1.30
	JUN	3615	1640	1597	-43	-2.64	1609	-32	-1.93
	JUL	1505	1122	1178	56	4.96	1191	69	6.16
	AUG	1088	649	633	-16	-2.39	635	-14	-2.16
	SEPT	770	680	669	-12	-1.73	620	-61	-8.92
	OCT	834	788	786	-2	-0.25	762	-26	-3.28
	NOV	800	892	877	-15	-1.73	864	-28	-3.18
	DEC	644	713	698	-15	-2.09	696	-17	-2.40
	JAN	642	707	692	-15	-2.11	692	-15	-2.07
	FEB	740	715	711	-4	-0.62	700	-15	-2.06
	MAR	896	717	713	-4	-0.54	709	-7	-1.01
1971	APR	1543	1118	1118	0	-0.03	1123	5	0.42
	MAY	2882	1798	1786	-11	-0.64	1795	-3	-0.17
	JUN	3763	2556	2541	-15	-0.58	2553	-3	-0.12
	JUL	2290	1252	1242	-10	-0.79	1255	4	0.29
	AUG	1055	588	572	-16	-2.75	585	-3	-0.47
	SEPT	810	658	646	-12	-1.79	636	-22	-3.35
	OCT	727	678	676	-2	-0.31	652	-27	-3.96
	NOV	761	826	810	-16	-1.89	811	-15	-1.77
	DEC	620	706	691	-15	-2.14	696	-10	-1.47
	JAN	567	655	639	-15	-2.31	644	-11	-1.64
	FEB	619	693	689	-4	-0.64	685	-8	-1.19
	MAR	815	661	657	-4	-0.58	645	-17	-2.51
1972	APR	993	680	681	2	0.22	684	4	0.57
	MAY	1659	777	769	-8	-1.08	777	0	0.00
	JUN	2017	757	745	-12	-1.56	757	0	0.00
	JUL	1011	682	662	-20	-2.97	675	-7	-1.00
	AUG	930	828	830	1	0.15	800	-28	-3.38
	SEPT	755	719	719	0	0.00	681	-38	-5.31
	OCT	655	641	636	-4	-0.69	617	-23	-3.66
	NOV	759	804	784	-20	-2.46	790	-14	-1.76
	DEC	527	624	604	-19	-3.12	612	-12	-1.90
	JAN	519	605	585	-19	-3.22	594	-11	-1.78
	FEB	523	606	597	-9	-1.48	597	-9	-1.54
	MAR	541	473	467	-5	-1.13	470	-3	-0.65
1973	APR	683	609	607	-2	-0.30	606	-3	-0.44
	MAY	2394	1444	1431	-14	-0.94	1439	-5	-0.36
	JUN	2872	1674	1657	-17	-1.01	1669	-5	-0.31
	JUL	2913	1869	1859	-10	-0.53	1872	4	0.19
	AUG	1201	849	833	-16	-1.83	846	-3	-0.36
	SEPT	851	702	690	-12	-1.68	670	-32	-4.52

Rock Creek Reservoir Analysis -- Colorado River At Kremmling Gage

Water Year	Month	Historic Kremmlin Flows (cfs)	Simulate Base Flows (cfs)	Simulated Project Flows (cfs)	West Slope Sales: Change In Flows (cfs)	West Slope Sales: Percent Change	Metro Denver Lease: Simulated Project Flows (cfs)	Metro Denver Lease: Change In Flows (cfs)	Metro Denver Lease: Percent Change
		1	2	3	4	5	6	7	8
	OCT	903	738	736	-2	-0.27	729	-9	-1.21
	NOV	835	785	770	-15	-1.96	773	-13	-1.60
	DEC	611	695	680	-15	-2.17	685	-10	-1.45
	JAN	596	699	684	-15	-2.16	688	-11	-1.51
	FEB	591	683	678	-4	-0.65	677	-5	-0.79
	MAR	887	733	729	-4	-0.53	721	-12	-1.62
1974	APR	1187	961	961	0	-0.02	960	-1	-0.09
	MAY	3527	2371	2357	-14	-0.57	2366	-5	-0.22
	JUN	3289	1879	1864	-15	-0.79	1876	-3	-0.16
	JUL	1555	1102	1092	-10	-0.89	1106	4	0.32
	AUG	1007	586	585	-1	-0.15	579	-7	-1.17
	SEPT	996	621	609	-12	-1.90	591	-29	-4.74
	OCT	790	794	790	-3	-0.41	775	-19	-2.38
	NOV	631	768	750	-18	-2.32	756	-12	-1.60
	DEC	521	658	641	-17	-2.61	650	-9	-1.36
	JAN	513	650	633	-17	-2.65	642	-8	-1.23
	FEB	536	676	669	-7	-0.98	669	-6	-0.96
	MAR	562	532	528	-5	-0.85	527	-5	-0.92
1975	APR	899	611	609	-1	-0.19	610	0	-0.06
	MAY	1523	929	917	-13	-1.36	925	-4	-0.45
	JUN	1825	1092	1076	-16	-1.46	1087	-4	-0.38
	JUL	1591	1053	1043	-10	-0.93	1056	4	0.34
	AUG	1103	728	712	-16	-2.16	697	-31	-4.27
	SEPT	862	670	670	0	0.00	631	-38	-5.75
	OCT	768	631	628	-3	-0.47	614	-16	-2.55
	NOV	701	822	805	-17	-2.12	813	-9	-1.12
	DEC	575	705	687	-17	-2.42	698	-7	-0.97
	JAN	563	693	676	-17	-2.46	685	-8	-1.15
	FEB	598	695	688	-6	-0.90	688	-7	-0.98
	MAR	799	543	538	-4	-0.80	539	-3	-0.63
1976	APR	782	616	617	1	0.19	619	3	0.46
	MAY	1292	761	752	-8	-1.10	761	0	0.00
	JUN	1179	627	615	-12	-1.88	627	0	0.00
	JUL	662	546	524	-22	-4.06	538	-9	-1.61
	AUG	805	813	814	1	0.15	795	-18	-2.20
	SEPT	845	663	663	0	0.00	619	-44	-6.62
	OCT	653	668	663	-4	-0.66	632	-36	-5.36
	NOV	585	643	623	-20	-3.08	629	-15	-2.27
	DEC	573	635	615	-19	-3.07	629	-6	-0.92
	JAN	488	569	549	-19	-3.43	564	-5	-0.94
	FEB	440	426	424	-2	-0.54	426	0	-0.04
	MAR	331	326	324	-2	-0.59	325	-2	-0.50
1977	APR	639	607	609	2	0.39	607	0	0.03
	MAY	477	512	512	0	0.08	521	9	1.72
	JUN	519	508	499	-9	-1.69	479	-28	-5.60
	JUL	923	975	977	3	0.26	876	-99	-10.15
	AUG	1031	1099	1076	-23	-2.05	784	-315	-28.64
	SEPT	923	973	940	-32	-3.34	929	-44	-4.52

Rock Creek Reservoir Analysis -- Colorado River At Kremmling Gage

Water Year	Month	Historic Kremmlin Flows (cfs)	Simulate Base Flows (cfs)	|--- West Slope Sales --| Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change	|--Metro Denver Lease--| Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change
		1	2	3	4	5	6	7	8
	OCT	556	643	622	-21	-3.24	595	-48	-7.42
	NOV	352	400	381	-19	-4.70	388	-11	-2.80
	DEC	363	407	389	-18	-4.35	391	-16	-4.02
	JAN	124	393	378	-14	-3.60	382	-10	-2.65
	FEB	452	382	378	-5	-1.26	375	-8	-1.98
	MAR	465	452	447	-4	-0.96	444	-8	-1.69
1978	APR	774	695	693	-2	-0.34	689	-7	-0.94
	MAY	1750	1153	1145	-8	-0.73	1153	0	0.00
	JUN	1970	1374	1363	-12	-0.86	1374	0	0.00
	JUL	1138	551	538	-13	-2.43	551	0	0.00
	AUG	835	828	829	1	0.15	802	-26	-3.12
	SEPT	896	807	796	-12	-1.46	769	-38	-4.77
	OCT	746	789	786	-4	-0.45	770	-19	-2.43
	NOV	740	747	728	-19	-2.49	737	-10	-1.30
	DEC	525	557	539	-18	-3.27	546	-11	-1.96
	JAN	514	554	535	-18	-3.29	538	-15	-2.79
	FEB	509	540	533	-8	-1.39	527	-14	-2.50
	MAR	462	482	477	-5	-1.00	469	-14	-2.83
1979	APR	725	830	829	-1	-0.16	879	49	5.85
	MAY	2139	1547	1531	-16	-1.03	1540	-8	-0.49
	JUN	2443	1613	1597	-16	-1.01	1609	-5	-0.28
	JUL	2113	1082	1072	-10	-0.91	1085	4	0.33
	AUG	948	842	929	87	10.28	942	100	11.87
	SEPT	826	627	616	-12	-1.88	600	-27	-4.34
	OCT	775	664	653	-11	-1.62	639	-24	-3.68
	NOV	592	663	631	-32	-4.88	630	-33	-5.02
	DEC	573	669	637	-32	-4.79	643	-26	-3.87
	JAN	522	631	599	-32	-5.08	597	-34	-5.39
	FEB	534	617	595	-22	-3.49	587	-30	-4.84
	MAR	568	462	453	-9	-1.93	445	-16	-3.56
1980	APR	1028	710	703	-7	-0.95	703	-7	-0.97
	MAY	2869	1612	1593	-19	-1.21	1601	-11	-0.69
	JUN	2643	1133	1110	-23	-2.02	1122	-11	-0.98
	JUL	1191	954	944	-10	-1.03	957	4	0.38
	AUG	930	637	639	1	0.19	624	-14	-2.17
	SEPT	802	600	600	0	0.00	568	-33	-5.43
	OCT	591	640	635	-4	-0.66	620	-20	-3.10
	NOV	525	600	580	-20	-3.33	587	-14	-2.27
	DEC	498	568	549	-20	-3.46	556	-12	-2.12
	JAN	401	527	507	-20	-3.73	521	-5	-1.02
	FEB	353	371	368	-2	-0.67	372	1	0.34
	MAR	372	361	359	-2	-0.53	361	0	0.05
1981	APR	558	654	656	2	0.36	624	-30	-4.63
	MAY	659	661	661	0	0.06	658	-2	-0.34
	JUN	564	569	561	-9	-1.51	573	3	0.50
	JUL	602	587	589	3	0.43	596	9	1.55
	AUG	972	1056	1057	1	0.12	839	-217	-20.56
	SEPT	842	766	766	0	0.00	733	-33	-4.32

Rock Creek Reservoir Analysis -- Colorado River At Kremmling Gage

Water Year	Month	Historic Kremmlin Flows (cfs)	Simulate Base Flows (cfs)	West Slope Sales: Simulated Project Flows (cfs)	West Slope Sales: Change In Flows (cfs)	West Slope Sales: Percent Change	Metro Denver Lease: Simulated Project Flows (cfs)	Metro Denver Lease: Change In Flows (cfs)	Metro Denver Lease: Percent Change
		1	2	3	4	5	6	7	8
	OCT	576	543	543	-1	-0.09	534	-10	-1.77
	NOV	455	494	469	-25	-5.13	482	-12	-2.41
	DEC	376	448	422	-26	-5.87	436	-12	-2.69
	JAN	451	488	461	-26	-5.40	472	-16	-3.24
	FEB	429	452	437	-16	-3.49	439	-13	-2.94
	MAR	403	378	371	-7	-1.93	367	-11	-2.84
1982	APR	573	527	526	0	-0.03	510	-16	-3.10
	MAY	1113	846	837	-8	-0.99	846	0	0.00
	JUN	1592	904	892	-12	-1.30	904	0	0.00
	JUL	1221	873	841	-32	-3.66	855	-19	-2.12
	AUG	1133	896	882	-13	-1.50	896	0	0.00
	SEPT	841	746	746	0	0.00	752	6	0.86

TABLE A.4

Rock Creek Reservoir Analysis--Colorado River at Dotsero Gage

Metro Denver Lease and West Slope Sales

Summary Table

Rock Creek Reservoir Analysis -- Colorado River At Dotsero Gage

				¦--- West Slope Sales --¦			--Metro Denver Lease--¦		
Water Year	Month	Historic Dotsero Flows (cfs)	Simulate Base Flows (cfs)	Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change	Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change
		1	2	3	4	5	6	7	8
	OCT	1947	1789	1766	-23	-1.31	1766	-23	-1.31
	NOV	1366	1423	1413	-9	-0.65	1413	-9	-0.64
	DEC	1229	1173	1165	-8	-0.69	1165	-8	-0.69
	JAN	1264	1165	1157	-7	-0.61	1157	-7	-0.61
	FEB	1603	1397	1394	-3	-0.22	1394	-3	-0.22
	MAR	1961	1408	1406	-2	-0.12	1406	-2	-0.12
1962	APR	5601	4794	4719	-76	-1.58	4723	-72	-1.49
	MAY	8600	6718	6703	-14	-0.22	6713	-5	-0.07
	JUN	7243	6340	6324	-16	-0.26	6337	-3	-0.04
	JUL	4598	4144	4136	-8	-0.18	4146	3	0.06
	AUG	1737	1546	1555	9	0.58	1555	9	0.58
	SEPT	1185	995	1003	8	0.83	1003	8	0.83
	OCT	2038	1194	1194	0	-0.04	1194	0	-0.03
	NOV	1664	1230	1215	-14	-1.18	1215	-14	-1.18
	DEC	1100	996	983	-13	-1.32	983	-13	-1.34
	JAN	835	994	982	-12	-1.24	982	-12	-1.24
	FEB	887	954	952	-2	-0.19	952	-2	-0.19
	MAR	961	1011	1011	0	0.00	1011	0	0.00
1963	APR	1300	1411	1417	6	0.45	1417	6	0.45
	MAY	2461	2233	2153	-80	-3.59	2153	-80	-3.59
	JUN	1923	1906	1884	-22	-1.15	1884	-22	-1.15
	JUL	1021	1122	1122	0	0.00	1122	0	0.00
	AUG	1217	1536	1545	9	0.58	1546	10	0.65
	SEPT	1219	1156	1164	8	0.71	1164	8	0.71
	OCT	967	1068	1067	-1	-0.06	1067	0	-0.05
	NOV	875	946	931	-15	-1.58	931	-15	-1.58
	DEC	589	758	744	-14	-1.85	744	-14	-1.85
	JAN	563	734	721	-13	-1.77	721	-13	-1.77
	FEB	571	597	595	-2	-0.33	595	-2	-0.33
	MAR	610	585	585	0	0.00	585	0	0.00
1964	APR	1039	1030	1036	6	0.62	1037	7	0.64
	MAY	3179	2745	2627	-118	-4.28	2627	-118	-4.28
	JUN	3400	3173	3098	-75	-2.36	3098	-75	-2.36
	JUL	1544	1395	1417	21	1.53	1395	0	0.00
	AUG	1352	1149	1158	9	0.78	1158	9	0.78
	SEPT	1177	1013	1021	8	0.81	1030	17	1.73
	OCT	1015	1001	1000	-1	-0.08	1000	-1	-0.08
	NOV	814	896	881	-15	-1.69	881	-15	-1.67
	DEC	789	829	815	-14	-1.69	815	-14	-1.69
	JAN	743	786	773	-13	-1.66	773	-13	-1.66
	FEB	731	789	780	-9	-1.12	780	-9	-1.12
	MAR	755	808	804	-3	-0.42	804	-3	-0.42
1965	APR	1711	1528	1524	-4	-0.26	1524	-4	-0.26
	MAY	4123	3514	3354	-160	-4.54	3354	-160	-4.54
	JUN	7055	6634	6615	-19	-0.29	6531	-104	-1.56
	JUL	4189	3550	3538	-12	-0.34	3552	2	0.05
	AUG	2735	2352	2346	-6	-0.24	2346	-6	-0.24
	SEPT	1535	1419	1427	8	0.58	1427	8	0.58

Rock Creek Reservoir Analysis -- Colorado River At Dotsero Gage

			West Slope Sales				Metro Denver Lease		
Water Year	Month	Historic Dotsero Flows (cfs)	Simulate Base Flows (cfs)	Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change	Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change
		1	2	3	4	5	6	7	8
	OCT	1517	1519	1520	1	0.05	1520	1	0.05
	NOV	1405	1445	1433	-12	-0.83	1433	-12	-0.81
	DEC	1389	1319	1308	-11	-0.81	1308	-11	-0.81
	JAN	1223	1192	1182	-10	-0.82	1182	-10	-0.82
	FEB	1223	1020	1019	-1	-0.12	1019	-1	-0.12
	MAR	1434	1185	1185	0	0.00	1185	0	0.00
1966	APR	1365	1323	1338	15	1.13	1334	11	0.83
	MAY	2760	2425	2365	-60	-2.48	2365	-60	-2.48
	JUN	1706	1697	1697	0	0.00	1697	0	0.00
	JUL	1404	1150	1150	0	0.00	1150	0	0.00
	AUG	1237	1127	1136	9	0.79	1136	9	0.79
	SEPT	1142	1222	1230	8	0.67	1230	8	0.67
	OCT	1047	1029	1029	-1	-0.06	1029	-1	-0.06
	NOV	811	820	805	-15	-1.82	805	-15	-1.82
	DEC	659	665	651	-14	-2.10	651	-14	-2.10
	JAN	734	695	682	-13	-1.87	682	-13	-1.87
	FEB	751	629	627	-2	-0.29	627	-2	-0.29
	MAR	1031	924	924	0	0.00	924	0	0.00
1967	APR	1580	1497	1504	6	0.43	1504	6	0.43
	MAY	2641	2262	2156	-106	-4.68	2156	-106	-4.68
	JUN	3927	3340	3270	-70	-2.10	3270	-70	-2.10
	JUL	2051	1756	1756	0	-0.03	1756	0	-0.03
	AUG	1288	1198	1207	9	0.75	1207	9	0.75
	SEPT	1271	1210	1218	8	0.68	1218	8	0.68
	OCT	1084	1108	1106	-2	-0.22	1106	-2	-0.22
	NOV	1004	1061	1043	-18	-1.74	1043	-18	-1.73
	DEC	888	988	975	-13	-1.30	975	-13	-1.30
	JAN	779	891	880	-12	-1.33	880	-12	-1.33
	FEB	882	835	834	-2	-0.19	834	-2	-0.19
	MAR	913	781	781	0	0.00	781	0	0.00
1968	APR	1453	1027	1033	6	0.62	1033	6	0.62
	MAY	2661	2526	2349	-176	-6.98	2391	-134	-5.32
	JUN	5689	5015	4976	-39	-0.77	5015	0	0.00
	JUL	2137	1743	1735	-8	-0.43	1743	0	0.00
	AUG	2075	1700	1674	-27	-1.56	1674	-27	-1.56
	SEPT	1311	1195	1203	8	0.69	1203	8	0.69
	OCT	1250	1183	1184	1	0.08	1184	1	0.07
	NOV	1103	1191	1179	-12	-0.99	1179	-12	-0.99
	DEC	961	1032	1021	-11	-1.04	1021	-11	-1.04
	JAN	965	1046	1036	-10	-0.93	1036	-10	-0.95
	FEB	930	1010	1004	-6	-0.55	1004	-6	-0.57
	MAR	988	837	834	-2	-0.29	834	-2	-0.29
1969	APR	1988	1772	1699	-74	-4.15	1699	-74	-4.15
	MAY	4063	3471	3417	-54	-1.56	3444	-27	-0.78
	JUN	4253	3128	3114	-14	-0.44	3128	0	0.00
	JUL	2879	2007	1998	-9	-0.45	1998	-9	-0.45
	AUG	1477	1394	1403	9	0.64	1403	9	0.64
	SEPT	1251	1214	1222	8	0.68	1222	8	0.68

Rock Creek Reservoir Analysis -- Colorado River At Dotsero Gage

Water Year	Month	Historic Dotsero Flows (cfs)	Simulate Base Flows (cfs)	West Slope Sales: Simulated Project Flows (cfs)	West Slope Sales: Change In Flows (cfs)	West Slope Sales: Percent Change	Metro Denver Lease: Simulated Project Flows (cfs)	Metro Denver Lease: Change In Flows (cfs)	Metro Denver Lease: Percent Change
		1	2	3	4	5	6	7	8
	OCT	1425	1486	1486	0	-0.03	1486	0	-0.03
	NOV	1280	1287	1272	-14	-1.11	1272	-14	-1.11
	DEC	1066	1147	1133	-13	-1.16	1133	-13	-1.16
	JAN	960	1048	1035	-12	-1.18	1035	-12	-1.18
	FEB	1148	1139	1130	-8	-0.73	1130	-8	-0.73
	MAR	1221	1024	1021	-3	-0.32	1021	-3	-0.32
1970	APR	1653	1523	1511	-12	-0.78	1511	-12	-0.78
	MAY	8512	6926	6756	-170	-2.45	6691	-234	-3.38
	JUN	7643	5676	5631	-45	-0.80	5645	-32	-0.56
	JUL	3227	2846	2912	65	2.29	2916	69	2.43
	AUG	1833	1388	1380	-8	-0.56	1380	-8	-0.56
	SEPT	1598	1508	1508	0	0.00	1508	0	0.00
	OCT	1579	1531	1533	2	0.13	1532	2	0.12
	NOV	1352	1436	1426	-10	-0.69	1426	-10	-0.69
	DEC	1000	1061	1052	-9	-0.83	1052	-9	-0.84
	JAN	1034	1092	1084	-8	-0.72	1084	-8	-0.72
	FEB	1200	1172	1168	-4	-0.32	1168	-4	-0.32
	MAR	1469	1288	1286	-2	-0.15	1286	-2	-0.15
1971	APR	2684	2258	2207	-52	-2.29	2207	-52	-2.29
	MAY	5533	4452	4369	-83	-1.87	4326	-126	-2.84
	JUN	8216	7017	7000	-17	-0.24	7014	-3	-0.04
	JUL	4079	3043	3035	-8	-0.27	3047	4	0.12
	AUG	1755	1282	1273	-8	-0.66	1273	-8	-0.66
	SEPT	1572	1420	1420	0	0.00	1420	0	0.00
	OCT	1209	1158	1160	2	0.15	1160	2	0.17
	NOV	1206	1263	1252	-10	-0.80	1252	-10	-0.80
	DEC	1133	1211	1202	-9	-0.74	1202	-9	-0.74
	JAN	1049	1130	1122	-8	-0.71	1122	-8	-0.71
	FEB	1074	1145	1142	-4	-0.33	1142	-4	-0.33
	MAR	1385	1200	1198	-2	-0.16	1198	-2	-0.18
1972	APR	1807	1493	1499	5	0.36	1499	5	0.36
	MAY	3721	2843	2717	-126	-4.44	2733	-110	-3.87
	JUN	5675	4393	4379	-14	-0.31	4393	0	0.00
	JUL	1958	1632	1625	-7	-0.42	1625	-7	-0.42
	AUG	1450	1343	1352	9	0.67	1352	9	0.67
	SEPT	1378	1339	1347	8	0.62	1347	8	0.62
	OCT	1371	1354	1354	0	-0.04	1354	0	-0.04
	NOV	1397	1433	1419	-14	-1.00	1419	-14	-1.01
	DEC	1066	1155	1142	-13	-1.15	1142	-13	-1.15
	JAN	1022	1101	1088	-12	-1.12	1088	-13	-1.14
	FEB	1015	1096	1088	-8	-0.76	1088	-8	-0.76
	MAR	1110	1040	1036	-3	-0.33	1036	-3	-0.33
1973	APR	1283	1208	1210	2	0.18	1210	2	0.17
	MAY	5164	4218	4074	-143	-3.39	4065	-152	-3.61
	JUN	6996	5806	5787	-19	-0.32	5800	-5	-0.09
	JUL	5108	4067	4060	-7	-0.17	4070	4	0.09
	AUG	2137	1780	1772	-8	-0.44	1772	-8	-0.43
	SEPT	1398	1247	1247	0	0.00	1247	0	0.00

Rock Creek Reservoir Analysis -- Colorado River At Dotsero Gage

Water Year	Month	Historic Dotsero Flows (cfs)	Simulate Base Flows (cfs)	¦--- West Slope Sales -- Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change	¦--Metro Denver Lease--¦ Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change
		1	2	3	4	5	6	7	8
	OCT	1396	1229	1231	2	0.16	1231	2	0.16
	NOV	1266	1208	1198	-10	-0.82	1198	-10	-0.82
	DEC	1132	1209	1200	-9	-0.74	1200	-9	-0.74
	JAN	1048	1144	1136	-8	-0.70	1136	-8	-0.70
	FEB	1078	1166	1162	-4	-0.32	1162	-4	-0.32
	MAR	1462	1307	1305	-2	-0.15	1304	-2	-0.16
1974	APR	2050	1823	1827	4	0.21	1826	4	0.20
	MAY	7889	6736	6603	-133	-1.97	6635	-101	-1.50
	JUN	6774	5372	5355	-17	-0.31	5369	-3	-0.06
	JUL	2879	2429	2426	-2	-0.09	2432	4	0.15
	AUG	1700	1273	1280	7	0.54	1280	7	0.54
	SEPT	1467	1092	1092	0	0.00	1092	0	0.00
	OCT	1312	1314	1315	1	0.05	1315	1	0.05
	NOV	1148	1276	1264	-12	-0.96	1264	-12	-0.96
	DEC	1035	1164	1153	-11	-0.95	1153	-11	-0.95
	JAN	1040	1170	1160	-10	-0.86	1160	-10	-0.86
	FEB	1110	1247	1241	-6	-0.48	1241	-6	-0.48
	MAR	1067	1036	1033	-3	-0.25	1033	-3	-0.25
1975	APR	1573	1284	1287	3	0.24	1287	3	0.24
	MAY	3527	2938	2802	-136	-4.64	2833	-105	-3.56
	JUN	6346	5620	5602	-18	-0.32	5616	-4	-0.07
	JUL	4518	3982	3974	-8	-0.20	3986	4	0.09
	AUG	1953	1573	1565	-8	-0.51	1565	-8	-0.52
	SEPT	1450	1255	1263	8	0.66	1263	8	0.66
	OCT	1351	1212	1213	1	0.08	1213	1	0.08
	NOV	1266	1379	1367	-12	-0.87	1367	-12	-0.85
	DEC	1050	1172	1161	-11	-0.93	1161	-11	-0.93
	JAN	1006	1128	1118	-10	-0.88	1118	-10	-0.88
	FEB	1141	1236	1230	-6	-0.45	1230	-6	-0.45
	MAR	1302	1044	1042	-2	-0.23	1042	-3	-0.25
1976	APR	1544	1377	1382	5	0.38	1382	5	0.38
	MAY	3547	3019	2893	-126	-4.18	2898	-121	-4.02
	JUN	3808	3263	3249	-14	-0.42	3263	0	0.00
	JUL	1859	1746	1737	-9	-0.50	1737	-9	-0.50
	AUG	1464	1466	1475	9	0.61	1475	9	0.61
	SEPT	1381	1196	1204	8	0.69	1204	8	0.69
	OCT	1192	1205	1205	0	-0.04	1205	0	-0.04
	NOV	1003	1053	1039	-14	-1.36	1039	-14	-1.36
	DEC	854	908	895	-13	-1.47	895	-13	-1.47
	JAN	816	890	878	-12	-1.39	878	-12	-1.39
	FEB	786	770	768	-2	-0.21	768	-2	-0.23
	MAR	630	624	624	0	0.00	624	0	0.00
1977	APR	1123	1090	1097	6	0.59	1097	6	0.59
	MAY	1437	1473	1481	7	0.49	1481	7	0.49
	JUN	1631	1627	1630	3	0.20	1630	3	0.20
	JUL	1311	1360	1369	9	0.68	1369	9	0.69
	AUG	1371	1433	1442	9	0.63	1442	9	0.62
	SEPT	1232	1278	1286	8	0.64	1286	8	0.64

Rock Creek Reservoir Analysis -- Colorado River At Dotsero Gage

Water Year	Month	Historic Dotsero Flows (cfs)	Simulate Base Flows (cfs)	West Slope Sales: Simulated Project Flows (cfs)	West Slope Sales: Change In Flows (cfs)	West Slope Sales: Percent Change	Metro Denver Lease: Simulated Project Flows (cfs)	Metro Denver Lease: Change In Flows (cfs)	Metro Denver Lease: Percent Change
		1	2	3	4	5	6	7	8
	OCT	960	1045	1050	5	0.46	1051	6	0.59
	NOV	677	719	717	-2	-0.23	721	3	0.37
	DEC	726	765	764	-1	-0.18	767	2	0.28
	JAN	758	722	722	0	-0.05	723	1	0.09
	FEB	745	674	673	0	-0.04	674	0	0.05
	MAR	810	795	795	0	-0.03	796	0	0.06
1978	APR	1604	1525	1536	11	0.74	1526	1	0.09
	MAY	4178	3585	3461	-124	-3.45	3461	-124	-3.45
	JUN	7488	6901	6731	-170	-2.46	6731	-170	-2.46
	JUL	3075	2492	2485	-7	-0.28	2485	-7	-0.28
	AUG	1428	1416	1425	9	0.63	1449	33	2.32
	SEPT	1331	1243	1243	0	0.00	1243	0	0.00
	OCT	1216	1256	1257	0	0.03	1257	0	0.01
	NOV	1223	1222	1209	-13	-1.07	1209	-13	-1.07
	DEC	814	838	826	-12	-1.44	826	-12	-1.44
	JAN	755	788	777	-11	-1.40	777	-11	-1.40
	FEB	822	851	844	-7	-0.80	844	-7	-0.80
	MAR	906	925	922	-3	-0.32	922	-3	-0.32
1979	APR	1422	1527	1529	3	0.17	1529	2	0.15
	MAY	5412	4825	4599	-226	-4.68	4599	-226	-4.68
	JUN	7841	7019	6946	-73	-1.04	6862	-157	-2.23
	JUL	4415	3387	3383	-4	-0.13	3383	-4	-0.13
	AUG	1652	1541	1635	94	6.12	1635	94	6.12
	SEPT	1300	1101	1101	0	0.00	1101	0	0.02
	OCT	1249	1136	1130	-7	-0.60	1130	-7	-0.60
	NOV	1108	1171	1144	-27	-2.30	1144	-27	-2.31
	DEC	1081	1169	1143	-26	-2.21	1142	-26	-2.23
	JAN	1021	1122	1098	-25	-2.22	1098	-25	-2.22
	FEB	1026	1106	1085	-21	-1.89	1085	-21	-1.89
	MAR	1020	913	906	-7	-0.77	906	-7	-0.77
1980	APR	1645	1326	1323	-3	-0.20	1323	-3	-0.19
	MAY	5682	4429	4288	-141	-3.18	4210	-219	-4.94
	JUN	7134	5631	5607	-25	-0.44	5522	-109	-1.94
	JUL	2462	2228	2231	4	0.16	2231	4	0.16
	AUG	1433	1135	1144	9	0.79	1144	9	0.79
	SEPT	1341	1136	1144	8	0.73	1165	30	2.64
	OCT	1053	1099	1099	0	-0.03	1099	0	-0.03
	NOV	981	1048	1033	-14	-1.38	1033	-14	-1.38
	DEC	921	984	970	-13	-1.37	970	-13	-1.37
	JAN	753	873	860	-13	-1.43	860	-13	-1.43
	FEB	663	678	676	-2	-0.27	677	-2	-0.24
	MAR	668	656	656	0	0.00	656	0	0.00
1981	APR	1097	1191	1198	6	0.54	1198	6	0.54
	MAY	1735	1739	1645	-94	-5.43	1645	-94	-5.43
	JUN	2553	2566	2518	-48	-1.87	2502	-64	-2.50
	JUL	1352	1333	1342	9	0.70	1342	9	0.70
	AUG	1336	1415	1424	9	0.63	1424	9	0.62
	SEPT	1305	1225	1234	8	0.67	1234	8	0.67

Rock Creek Reservoir Analysis -- Colorado River At Dotsero Gage

Water Year	Month	Historic Dotsero Flows (cfs)	Simulate Base Flows (cfs)	West Slope Sales: Simulated Project Flows (cfs)	West Slope Sales: Change In Flows (cfs)	West Slope Sales: Percent Change	Metro Denver Lease: Simulated Project Flows (cfs)	Metro Denver Lease: Change In Flows (cfs)	Metro Denver Lease: Percent Change
		1	2	3	4	5	6	7	8
	OCT	1037	1003	1007	3	0.34	1007	3	0.34
	NOV	849	881	861	-20	-2.25	861	-20	-2.23
	DEC	726	791	770	-20	-2.55	770	-20	-2.55
	JAN	739	769	750	-19	-2.50	750	-19	-2.50
	FEB	741	762	747	-15	-1.98	747	-15	-1.96
	MAR	858	831	826	-5	-0.65	826	-5	-0.63
1982	APR	1257	1209	1213	4	0.32	1219	9	0.75
	MAY	3412	3148	3010	-138	-4.38	2925	-224	-7.11
	JUN	5833	5153	5139	-14	-0.26	5068	-85	-1.64
	JUL	3584	3239	3221	-19	-0.57	3221	-19	-0.57
	AUG	2056	1813	1807	-6	-0.31	1807	-6	-0.31
	SEPT	1551	1452	1460	8	0.57	1460	8	0.56

TABLE A.5

Muddy Creek Reservoir--Discharge Summary

Metro Denver Lease and West Slope Sales

MUDDY CREEK RESERVOIR OPERATIONS--DISCHARGE SUMMARY

WATER YEAR		INFLOW TO RES	---WEST SLOPE SALES--- FLOW BELOW RES	DIFF IN FLOW	PERCENT CHANGE	--METRO DENVER LEASE-- FLOW BELOW RES	DIFF IN FLOW	PERCENT CHANGE
		CFS	CFS	CFS	%	CFS	CFS	%
COL		1	2	3	4	5	6	7
	OCT	77	77	0	0	77	0	0
	NOV	61	82	22	36	97	36	60
	DEC	35	56	21	60	53	18	51
	JAN	53	74	21	40	65	12	22
	FEB	50	54	5	9	58	8	17
	MAR	29	33	4	14	29	0	2
1962	APR	539	465	-74	-14	463	-76	-14
	MAY	536	536	0	0	536	0	0
	JUN	238	238	0	0	238	0	0
	JUL	108	108	0	0	108	0	0
	AUG	59	75	15	26	59	0	0
	SEP	31	45	14	44	60	29	92
	OCT	0	7	7	1000*	26	26	1000*
	NOV	0	22	22	1000*	13	13	1000*
	DEC	0	21	21	1000*	3	3	1000*
	JAN	34	55	21	62	34	0	0
	FEB	47	51	5	10	50	3	7
	MAR	77	81	4	5	85	8	11
1963	APR	110	116	6	5	140	30	27
	MAY	144	31	-113	-78	35	-109	-76
	JUN	38	38	0	0	38	0	0
	JUL	17	33	15	91	47	30	173
	AUG	33	49	15	46	124	91	272
	SEP	2	16	14	670	54	52	2549
	OCT	16	23	7	44	115	100	634
	NOV	28	49	22	79	34	6	22
	DEC	22	43	21	96	22	0	0
	JAN	21	42	21	99	21	0	0
	FEB	23	27	5	20	23	0	1
	MAR	27	31	4	15	28	1	5
1964	APR	80	86	6	7	83	4	5
	MAY	201	73	-128	-64	13	-188	-94
	JUN	151	151	0	0	54	-96	-64
	JUL	58	73	15	27	58	0	0
	AUG	87	102	15	18	103	17	19
	SEP	12	26	14	111	101	89	721
	OCT	18	25	7	38	30	12	69
	NOV	23	45	22	95	33	10	45
	DEC	19	40	21	113	24	6	30
	JAN	17	38	21	122	23	5	31
	FEB	18	22	5	25	23	5	27
	MAR	15	19	4	27	20	4	28
1965	APR	134	140	6	4	136	2	2
	MAY	347	219	-128	-37	201	-146	-42
	JUN	349	349	0	0	349	0	0
	JUL	97	97	0	0	97	0	0

WATER YEAR		INFLOW TO RES	WEST SLOPE SALES FLOW BELOW RES	DIFF IN FLOW	PERCENT CHANGE	METRO DENVER LEASE FLOW BELOW RES	DIFF IN FLOW	PERCENT CHANGE
		CFS	CFS	CFS	%	CFS	CFS	%
	COL	1	2	3	4	5	6	7
	AUG	99	99	0	0	99	0	0
	SEP	57	71	14	24	58	1	2
	OCT	60	67	7	11	98	37	62
	NOV	54	76	22	40	82	27	51
	DEC	26	47	21	81	44	18	68
	JAN	44	65	21	48	52	8	19
	FEB	30	34	5	15	38	8	27
	MAR	64	68	4	6	73	9	14
1966	APR	77	83	6	8	95	18	23
	MAY	109	13	-96	-88	13	-96	-88
	JUN	15	29	14	90	15	0	0
	JUL	5	21	15	301	5	0	0
	AUG	4	19	15	431	37	34	943
	SEP	15	29	14	90	34	19	126
	OCT	40	47	7	17	54	13	34
	NOV	43	64	22	51	43	1	2
	DEC	25	46	21	84	25	0	0
	JAN	24	45	21	89	24	0	0
	FEB	32	36	5	14	32	0	0
	MAR	80	84	4	5	83	3	4
1967	APR	100	106	6	6	131	32	32
	MAY	154	13	-141	-92	25	-129	-84
	JUN	180	178	-2	-1	180	0	0
	JUL	59	59	0	0	59	0	0
	AUG	49	65	15	31	95	45	92
	SEP	47	60	14	29	90	43	92
	OCT	31	38	7	22	52	20	64
	NOV	38	60	22	57	48	10	25
	DEC	35	56	21	60	38	3	10
	JAN	46	67	21	46	52	6	12
	FEB	52	56	5	9	59	7	14
	MAR	49	53	4	8	49	1	1
1968	APR	99	105	6	6	99	0	0
	MAY	209	97	-113	-54	77	-133	-63
	JUN	280	280	0	0	280	0	0
	JUL	94	94	0	0	94	0	0
	AUG	113	113	0	0	113	0	0
	SEP	51	65	14	27	99	48	94
	OCT	45	52	7	15	73	28	63
	NOV	64	86	22	34	74	10	16
	DEC	54	75	21	39	58	4	8
	JAN	49	70	21	43	55	6	12
	FEB	47	52	5	10	49	2	4
	MAR	52	56	4	8	56	5	9
1969	APR	161	67	-95	-59	57	-105	-65
	MAY	190	190	0	0	190	0	0

MUDDY CREEK RESERVOIR OPERATIONS--DISCHARGE SUMMARY

WATER YEAR		INFLOW TO RES	¦----WEST SLOPE SALES----¦ FLOW BELOW RES	DIFF IN FLOW	PERCENT CHANGE	¦--METRO DENVER LEASE--¦ FLOW BELOW RES	DIFF IN FLOW	PERCENT CHANGE
		CFS	CFS	CFS	%	CFS	CFS	%
COL		1	2	3	4	5	6	7
	JUN	144	144	0	0	144	0	0
	JUL	68	68	0	0	68	0	0
	AUG	17	33	15	89	71	53	307
	SEP	27	40	14	51	77	50	189
	OCT	76	83	7	9	112	35	46
	NOV	61	83	22	36	73	12	20
	DEC	57	78	21	37	71	13	23
	JAN	60	81	21	35	73	13	21
	FEB	48	53	5	9	57	9	18
	MAR	63	67	4	6	71	8	13
1970	APR	159	164	6	4	170	12	7
	MAY	494	381	-113	-23	292	-202	-41
	JUN	348	348	0	0	348	0	0
	JUL	125	125	0	0	125	0	0
	AUG	74	90	15	21	86	12	16
	SEP	28	42	14	48	89	61	215
	OCT	99	106	7	7	128	30	30
	NOV	107	129	22	20	135	28	26
	DEC	85	106	21	25	101	16	19
	JAN	84	106	21	25	98	14	17
	FEB	100	104	5	5	114	14	14
	MAR	110	114	4	4	117	7	6
1971	APR	145	34	-111	-77	13	-132	-91
	MAY	212	212	0	0	162	-50	-23
	JUN	306	306	0	0	306	0	0
	JUL	319	319	0	0	319	0	0
	AUG	153	169	15	10	153	0	0
	SEP	120	134	14	11	142	22	18
	OCT	63	70	7	11	94	31	49
	NOV	44	65	22	50	57	14	32
	DEC	55	77	21	38	65	10	17
	JAN	28	49	21	75	38	10	35
	FEB	44	49	5	10	52	8	17
	MAR	78	82	4	5	94	16	20
1972	APR	123	129	6	5	126	3	2
	MAY	277	164	-113	-41	167	-110	-40
	JUN	262	262	0	0	262	0	0
	JUL	71	87	15	22	71	0	0
	AUG	41	57	15	38	84	43	103
	SEP	39	53	14	35	89	50	128
	OCT	55	62	7	12	80	25	45
	NOV	39	61	22	55	48	9	23
	DEC	17	39	21	121	24	7	38
	JAN	11	32	21	198	16	5	50
	FEB	9	13	5	52	13	4	47
	MAR	14	18	4	29	15	1	8

MUDDY CREEK RESERVOIR OPERATIONS--DISCHARGE SUMMARY

WATER YEAR		INFLOW TO RES	¦----WEST SLOPE SALES----¦ FLOW BELOW RES	DIFF IN FLOW	PERCENT CHANGE	¦--METRO DENVER LEASE--¦ FLOW BELOW RES	DIFF IN FLOW	PERCENT CHANGE
		CFS	CFS	CFS	%	CFS	CFS	%
COL		1	2	3	4	5	6	7
1973	APR	107	113	6	6	113	6	5
	MAY	451	323	-128	-28	304	-147	-33
	JUN	298	298	0	0	298	0	0
	JUL	148	148	0	0	148	0	0
	AUG	89	89	0	0	89	0	0
	SEP	37	51	14	36	69	32	85
	OCT	37	44	7	19	50	13	35
	NOV	48	70	22	45	60	12	25
	DEC	47	68	21	45	56	9	20
	JAN	48	69	21	44	57	10	20
	FEB	40	45	5	11	45	5	12
	MAR	80	84	4	5	91	11	14
1974	APR	143	149	6	4	149	6	4
	MAY	467	370	-97	-21	372	-95	-20
	JUN	225	225	0	0	225	0	0
	JUL	110	110	0	0	110	0	0
	AUG	54	69	15	29	73	19	36
	SEP	7	21	14	183	37	29	395
	OCT	45	52	7	15	66	21	48
	NOV	52	73	22	42	61	9	18
	DEC	37	58	21	57	43	6	16
	JAN	30	51	21	70	35	5	17
	FEB	38	43	5	12	42	4	9
	MAR	48	52	4	8	52	4	8
1975	APR	99	105	6	6	103	4	4
	MAY	330	217	-113	-34	229	-101	-30
	JUN	394	394	0	0	394	0	0
	JUL	122	122	0	0	122	0	0
	AUG	78	93	15	20	106	29	37
	SEP	36	50	14	38	86	50	139
	OCT	49	56	7	14	68	19	39
	NOV	58	80	22	37	65	7	12
	DEC	68	89	21	31	72	4	6
	JAN	60	81	21	35	66	5	9
	FEB	57	61	5	8	61	4	8
	MAR	83	87	4	5	85	2	3
1976	APR	130	136	6	5	133	3	3
	MAY	292	179	-113	-39	170	-121	-42
	JUN	132	132	0	0	132	0	0
	JUL	56	56	0	0	56	0	0
	AUG	54	69	15	29	86	33	61
	SEP	31	45	14	44	87	56	179
	OCT	39	46	7	18	76	37	95
	NOV	31	53	22	69	41	10	30
	DEC	49	70	21	43	50	1	1
	JAN	10	31	21	207	10	0	2

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MUDDY CREEK RESERVOIR OPERATIONS--DISCHARGE SUMMARY

WATER	YEAR	INFLOW TO RES	WEST SLOPE SALES FLOW BELOW RES	WEST SLOPE SALES DIFF IN FLOW	WEST SLOPE SALES PERCENT CHANGE	METRO DENVER LEASE FLOW BELOW RES	METRO DENVER LEASE DIFF IN FLOW	METRO DENVER LEASE PERCENT CHANGE
		CFS	CFS	CFS	%	CFS	CFS	%
	COL	1	2	3	4	5	6	7
	FEB	30	34	5	15	31	1	5
	MAR	32	37	4	13	36	3	10
1977	APR	88	94	6	7	96	7	8
	MAY	67	77	10	14	67	0	0
	JUN	14	28	14	96	46	32	222
	JUL	16	32	15	94	131	115	700
	AUG	27	66	39	144	352	325	1191
	SEP	17	63	46	267	67	49	287
	OCT	36	64	28	78	88	52	145
	NOV	32	68	36	111	53	21	64
	DEC	24	57	33	138	49	25	102
	JAN	39	69	30	75	41	1	3
	FEB	40	49	9	23	40	0	0
	MAR	72	78	7	9	72	0	0
1978	APR	183	198	15	8	183	0	0
	MAY	415	26	-389	-94	13	-402	-97
	JUN	395	395	0	0	24	-371	-94
	JUL	121	121	0	0	121	0	0
	AUG	49	65	15	31	90	40	82
	SEP	18	31	14	77	56	38	218
	OCT	43	50	7	16	65	21	49
	NOV	52	74	22	42	58	6	11
	DEC	62	83	21	34	69	7	11
	JAN	51	72	21	41	63	12	23
	FEB	53	57	5	8	63	10	18
	MAR	39	43	4	10	52	12	31
1979	APR	152	158	6	4	157	5	4
	MAY	597	484	-113	-19	448	-149	-25
	JUN	422	422	0	0	422	0	0
	JUL	91	91	0	0	91	0	0
	AUG	71	87	15	22	71	0	0
	SEP	4	18	14	347	31	27	697
	OCT	27	34	7	26	47	20	72
	NOV	47	69	22	46	63	15	33
	DEC	38	59	21	56	46	8	21
	JAN	46	67	21	46	62	16	35
	FEB	45	49	5	10	57	12	27
	MAR	39	43	4	11	49	11	28
1980	APR	151	157	6	4	156	5	4
	MAY	512	400	-113	-22	400	-112	-22
	JUN	169	169	0	0	169	0	0
	JUL	77	77	0	0	77	0	0
	AUG	79	94	15	20	107	28	36
	SEP	31	44	14	44	75	44	144
	OCT	47	54	7	15	68	21	46
	NOV	46	68	22	48	54	8	18

MUDDY CREEK RESERVOIR OPERATIONS--DISCHARGE SUMMARY

WATER YEAR		INFLOW TO RES	----WEST SLOPE SALES---- FLOW BELOW RES	DIFF IN FLOW	PERCENT CHANGE	--METRO DENVER LEASE-- FLOW BELOW RES	DIFF IN FLOW	PERCENT CHANGE
		CFS	CFS	CFS	%	CFS	CFS	%
	COL	1	2	3	4	5	6	7
	DEC	38	59	21	56	44	7	18
	JAN	36	57	21	59	36	0	0
	FEB	52	56	5	9	52	0	0
	MAR	44	48	4	9	46	1	3
1981	APR	58	64	6	10	95	38	65
	MAY	115	13	-102	-89	13	-102	-89
	JUN	74	62	-11	-15	29	-45	-61
	JUL	77	92	15	20	83	7	9
	AUG	41	56	15	38	272	232	571
	SEP	36	49	14	38	81	45	125
	OCT	59	66	7	12	74	15	25
	NOV	55	77	22	40	56	2	3
	DEC	48	69	21	44	48	0	0
	JAN	60	81	21	35	64	4	6
	FEB	49	53	5	9	50	1	3
	MAR	24	28	4	17	31	7	30
1982	APR	43	49	6	14	64	21	49
	MAY	270	142	-128	-47	13	-257	-95
	JUN	298	298	0	0	222	-76	-26
	JUL	106	106	0	0	106	0	0
	AUG	39	39	0	0	39	0	0
	SEP	51	51	0	0	51	0	0
	AVG	94	94	0	0	94	0	0
	MIN	0	7	-389	-94	3	-402	-97
	MAX	597	536	46	670	536	325	2549

* actual value equal to infinity

TABLE A.6

Muddy Creek Reservoir Analysis--Colorado River at Dotsero Gage

Metro Denver Lease and West Slope Sales

Summary Table

Muddy Creek Reservoir Analysis -- Colorado River At Dotsero Gage

Water Year	Month	Historic Dotsero Flows (cfs)	Simulate Base Flows (cfs)	West Slope Sales: Simulated Project Flows (cfs)	West Slope Sales: Change In Flows (cfs)	West Slope Sales: Percent Change	Metro Denver Lease: Simulated Project Flows (cfs)	Metro Denver Lease: Change In Flows (cfs)	Metro Denver Lease: Percent Change
		1	2	3	4	5	6	7	8
	OCT	1947	1789	1781	-9	-0.49	1787	-2	-0.11
	NOV	1366	1423	1413	-9	-0.65	1413	-9	-0.64
	DEC	1229	1173	1165	-8	-0.69	1165	-8	-0.69
	JAN	1264	1165	1157	-7	-0.61	1157	-7	-0.61
	FEB	1603	1397	1394	-3	-0.22	1394	-3	-0.22
	MAR	1961	1408	1406	-2	-0.12	1406	-2	-0.12
1962	APR	5601	4794	4719	-76	-1.58	4723	-72	-1.49
	MAY	8600	6718	6703	-14	-0.22	6713	-5	-0.07
	JUN	7243	6340	6324	-16	-0.26	6337	-3	-0.04
	JUL	4598	4144	4131	-13	-0.31	4146	3	0.06
	AUG	1737	1546	1555	9	0.58	1555	9	0.58
	SEPT	1185	995	1003	8	0.83	1003	8	0.83
	OCT	2038	1194	1194	0	-0.04	1194	0	-0.03
	NOV	1664	1230	1215	-14	-1.18	1215	-14	-1.18
	DEC	1100	996	983	-13	-1.32	983	-13	-1.34
	JAN	835	994	982	-12	-1.24	982	-12	-1.24
	FEB	887	954	952	-2	-0.19	952	-2	-0.19
	MAR	961	1011	1011	0	0.00	1011	0	0.00
1963	APR	1300	1411	1417	6	0.45	1417	6	0.45
	MAY	2461	2233	2111	-123	-5.49	2124	-109	-4.88
	JUN	1923	1906	1892	-14	-0.71	1906	0	0.00
	JUL	1021	1122	1122	0	0.00	1122	0	0.00
	AUG	1217	1536	1545	9	0.58	1545	9	0.58
	SEPT	1219	1156	1164	8	0.71	1164	8	0.71
	OCT	967	1068	1067	-1	-0.06	1067	0	-0.05
	NOV	875	946	931	-15	-1.58	931	-15	-1.58
	DEC	589	758	744	-14	-1.85	744	-14	-1.85
	JAN	563	734	721	-13	-1.77	721	-13	-1.77
	FEB	571	597	595	-2	-0.33	595	-2	-0.33
	MAR	610	585	585	0	0.00	585	0	0.00
1964	APR	1039	1030	1036	6	0.62	1037	7	0.64
	MAY	3179	2745	2607	-138	-5.03	2557	-188	-6.84
	JUN	3400	3173	3160	-14	-0.43	3077	-96	-3.04
	JUL	1544	1395	1395	0	0.00	1395	0	0.00
	AUG	1352	1149	1158	9	0.78	1158	9	0.78
	SEPT	1177	1013	1021	8	0.81	1021	8	0.83
	OCT	1015	1001	1000	-1	-0.08	1000	-1	-0.08
	NOV	814	896	881	-15	-1.69	881	-15	-1.67
	DEC	789	829	815	-14	-1.69	815	-14	-1.69
	JAN	743	786	773	-13	-1.66	773	-13	-1.66
	FEB	731	789	780	-9	-1.12	780	-9	-1.12
	MAR	755	808	804	-3	-0.42	804	-3	-0.42
1965	APR	1711	1528	1524	-4	-0.26	1524	-4	-0.26
	MAY	4123	3514	3376	-138	-3.93	3368	-146	-4.16
	JUN	7055	6634	6615	-19	-0.29	6629	-5	-0.08
	JUL	4189	3550	3536	-14	-0.39	3552	2	0.05
	AUG	2735	2352	2331	-21	-0.90	2346	-6	-0.24
	SEPT	1535	1419	1427	8	0.58	1427	8	0.58

Muddy Creek Reservoir Analysis -- Colorado River At Dotsero Gage

Water Year	Month	Historic Dotsero Flows (cfs)	Simulate Base Flows (cfs)	¦--- West Slope Sales --¦ Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change	¦--Metro Denver Lease--¦ Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change
		1	2	3	4	5	6	7	8
	OCT	1517	1519	1520	1	0.05	1520	1	0.05
	NOV	1405	1445	1433	-12	-0.83	1433	-12	-0.81
	DEC	1389	1319	1308	-11	-0.81	1308	-11	-0.81
	JAN	1223	1192	1182	-10	-0.82	1182	-10	-0.82
	FEB	1223	1020	1019	-1	-0.12	1019	-1	-0.12
	MAR	1434	1185	1185	0	0.00	1185	0	0.00
1966	APR	1365	1323	1329	6	0.48	1329	6	0.48
	MAY	2760	2425	2319	-105	-4.35	2329	-96	-3.95
	JUN	1706	1697	1697	0	0.00	1697	0	0.00
	JUL	1404	1150	1150	0	0.00	1150	0	0.00
	AUG	1237	1127	1136	9	0.79	1136	9	0.79
	SEPT	1142	1222	1230	8	0.67	1230	8	0.67
	OCT	1047	1029	1029	-1	-0.06	1029	-1	-0.06
	NOV	811	820	805	-15	-1.82	805	-15	-1.82
	DEC	659	665	651	-14	-2.10	651	-14	-2.10
	JAN	734	695	682	-13	-1.87	682	-13	-1.87
	FEB	751	629	628	-2	-0.29	628	-2	-0.29
	MAR	1031	924	924	0	0.00	924	0	0.00
1967	APR	1580	1497	1504	6	0.43	1504	6	0.43
	MAY	2641	2262	2111	-151	-6.66	2126	-136	-6.01
	JUN	3927	3340	3324	-16	-0.47	3340	0	0.00
	JUL	2051	1756	1741	-15	-0.88	1756	0	0.00
	AUG	1288	1198	1207	9	0.75	1207	9	0.75
	SEPT	1271	1210	1218	8	0.68	1218	8	0.68
	OCT	1084	1108	1106	-2	-0.22	1106	-2	-0.22
	NOV	1004	1061	1043	-18	-1.74	1043	-18	-1.73
	DEC	888	988	975	-13	-1.30	975	-13	-1.30
	JAN	779	891	880	-12	-1.33	880	-12	-1.33
	FEB	882	835	834	-2	-0.19	834	-2	-0.19
	MAR	913	781	781	0	0.00	781	0	0.00
1968	APR	1453	1027	1033	6	0.62	1033	6	0.62
	MAY	2661	2526	2403	-123	-4.85	2393	-133	-5.25
	JUN	5689	5015	5001	-14	-0.27	5015	0	0.00
	JUL	2137	1743	1727	-15	-0.89	1743	0	0.00
	AUG	2075	1700	1658	-42	-2.47	1674	-27	-1.56
	SEPT	1311	1195	1203	8	0.69	1203	8	0.69
	OCT	1250	1183	1184	1	0.08	1184	1	0.07
	NOV	1103	1191	1179	-12	-0.99	1179	-12	-0.99
	DEC	961	1032	1021	-11	-1.04	1021	-11	-1.04
	JAN	965	1046	1036	-10	-0.93	1036	-10	-0.95
	FEB	930	1010	1004	-6	-0.55	1004	-6	-0.57
	MAR	988	837	834	-2	-0.29	834	-2	-0.29
1969	APR	1988	1772	1677	-95	-5.38	1670	-102	-5.74
	MAY	4063	3471	3461	-10	-0.28	3471	0	0.00
	JUN	4253	3128	3114	-14	-0.44	3128	0	0.00
	JUL	2879	2007	1983	-24	-1.22	1998	-9	-0.45
	AUG	1477	1394	1403	9	0.64	1403	9	0.64
	SEPT	1251	1214	1222	8	0.68	1222	8	0.68

Muddy Creek Reservoir Analysis -- Colorado River At Dotsero Gage

Water Year	Month	Historic Dotsero Flows (cfs)	Simulate Base Flows (cfs)	¦--- West Slope Sales --¦ Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change	¦--Metro Denver Lease--¦ Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change
		1	2	3	4	5	6	7	8
	OCT	1425	1486	1486	0	-0.03	1486	0	-0.03
	NOV	1280	1287	1273	-14	-1.11	1273	-14	-1.11
	DEC	1066	1147	1133	-13	-1.16	1133	-13	-1.16
	JAN	960	1048	1035	-12	-1.18	1035	-12	-1.18
	FEB	1148	1139	1130	-8	-0.73	1130	-8	-0.73
	MAR	1221	1024	1021	-3	-0.32	1021	-3	-0.32
1970	APR	1653	1523	1511	-12	-0.78	1511	-12	-0.78
	MAY	8512	6926	6771	-154	-2.22	6691	-234	-3.38
	JUN	7643	5676	5631	-45	-0.80	5645	-32	-0.56
	JUL	3227	2846	2900	54	1.88	2916	69	2.43
	AUG	1833	1388	1380	-8	-0.56	1380	-8	-0.56
	SEPT	1598	1508	1508	0	0.00	1508	0	0.00
	OCT	1579	1531	1533	2	0.13	1532	2	0.12
	NOV	1352	1436	1426	-10	-0.69	1426	-10	-0.69
	DEC	1000	1061	1052	-9	-0.83	1052	-9	-0.84
	JAN	1034	1092	1084	-8	-0.72	1084	-8	-0.72
	FEB	1200	1172	1168	-4	-0.32	1168	-4	-0.32
	MAR	1469	1288	1286	-2	-0.15	1286	-2	-0.15
1971	APR	2684	2258	2146	-113	-4.99	2131	-128	-5.65
	MAY	5533	4452	4440	-13	-0.29	4400	-53	-1.19
	JUN	8216	7017	7000	-17	-0.24	7014	-3	-0.04
	JUL	4079	3043	3031	-12	-0.39	3047	4	0.12
	AUG	1755	1282	1273	-8	-0.66	1273	-8	-0.66
	SEPT	1572	1420	1420	0	0.00	1420	0	0.00
	OCT	1209	1158	1160	2	0.15	1160	2	0.17
	NOV	1206	1263	1253	-10	-0.80	1253	-10	-0.80
	DEC	1133	1211	1202	-9	-0.74	1202	-9	-0.74
	JAN	1049	1130	1122	-8	-0.71	1122	-8	-0.71
	FEB	1074	1145	1142	-4	-0.33	1142	-4	-0.33
	MAR	1385	1200	1198	-2	-0.16	1198	-2	-0.18
1972	APR	1807	1493	1499	5	0.36	1499	5	0.36
	MAY	3721	2843	2720	-123	-4.31	2733	-110	-3.87
	JUN	5675	4393	4379	-14	-0.31	4393	0	0.00
	JUL	1958	1632	1625	-7	-0.42	1625	-7	-0.42
	AUG	1450	1343	1352	9	0.67	1352	9	0.67
	SEPT	1378	1339	1347	8	0.61	1347	8	0.61
	OCT	1371	1354	1354	0	-0.04	1354	0	-0.04
	NOV	1397	1433	1419	-14	-1.00	1419	-14	-1.01
	DEC	1066	1155	1142	-13	-1.15	1142	-13	-1.15
	JAN	1022	1101	1088	-12	-1.12	1088	-13	-1.14
	FEB	1015	1096	1088	-8	-0.76	1088	-8	-0.76
	MAR	1110	1040	1036	-3	-0.33	1036	-3	-0.33
1973	APR	1283	1208	1210	2	0.18	1210	2	0.17
	MAY	5164	4218	4074	-143	-3.39	4065	-152	-3.61
	JUN	6996	5806	5787	-19	-0.32	5800	-5	-0.09
	JUL	5108	4067	4055	-12	-0.29	4070	4	0.09
	AUG	2137	1780	1756	-23	-1.31	1771	-9	-0.49
	SEPT	1398	1247	1247	0	0.00	1247	0	0.00

Muddy Creek Reservoir Analysis -- Colorado River At Dotsero Gage

				¦--- West Slope Sales	--	--¦	--Metro Denver Lease	--¦	
Water Year	Month	Historic Dotsero Flows (cfs)	Simulate Base Flows (cfs)	Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change	Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change
		1	2	3	4	5	6	7	8
	OCT	1396	1229	1231	2	0.16	1231	2	0.16
	NOV	1266	1208	1198	-10	-0.82	1198	-10	-0.82
	DEC	1132	1209	1200	-9	-0.74	1200	-9	-0.74
	JAN	1048	1144	1136	-8	-0.70	1136	-8	-0.70
	FEB	1078	1166	1162	-4	-0.32	1162	-4	-0.32
	MAR	1462	1307	1305	-2	-0.15	1304	-2	-0.16
1974	APR	2050	1823	1827	4	0.21	1826	4	0.20
	MAY	7889	6736	6624	-112	-1.67	6636	-100	-1.49
	JUN	6774	5372	5355	-17	-0.31	5369	-3	-0.06
	JUL	2879	2429	2417	-12	-0.49	2432	4	0.15
	AUG	1700	1273	1280	7	0.54	1280	7	0.54
	SEPT	1467	1092	1092	0	0.00	1092	0	0.00
	OCT	1312	1314	1315	1	0.05	1315	1	0.05
	NOV	1148	1276	1264	-12	-0.96	1264	-12	-0.96
	DEC	1035	1164	1153	-11	-0.95	1153	-11	-0.95
	JAN	1040	1170	1160	-10	-0.86	1160	-10	-0.86
	FEB	1110	1247	1241	-6	-0.48	1241	-6	-0.48
	MAR	1067	1036	1033	-3	-0.25	1033	-3	-0.25
1975	APR	1573	1284	1287	3	0.24	1287	3	0.24
	MAY	3527	2938	2811	-127	-4.31	2833	-105	-3.56
	JUN	6346	5620	5602	-18	-0.32	5616	-4	-0.07
	JUL	4518	3982	3970	-12	-0.30	3986	4	0.09
	AUG	1953	1573	1565	-8	-0.51	1565	-8	-0.52
	SEPT	1450	1255	1263	8	0.66	1263	8	0.66
	OCT	1351	1212	1213	1	0.08	1213	1	0.08
	NOV	1266	1379	1367	-12	-0.87	1367	-12	-0.85
	DEC	1050	1172	1161	-11	-0.93	1161	-11	-0.93
	JAN	1006	1128	1118	-10	-0.88	1118	-10	-0.88
	FEB	1141	1236	1230	-6	-0.45	1230	-6	-0.45
	MAR	1302	1044	1042	-2	-0.23	1042	-3	-0.25
1976	APR	1544	1377	1382	5	0.38	1382	5	0.38
	MAY	3547	3019	2897	-123	-4.06	2898	-121	-4.02
	JUN	3808	3263	3249	-14	-0.42	3263	0	0.00
	JUL	1859	1746	1722	-24	-1.39	1737	-9	-0.50
	AUG	1464	1466	1475	9	0.61	1475	9	0.61
	SEPT	1381	1196	1204	8	0.69	1204	8	0.69
	OCT	1192	1205	1205	0	-0.04	1205	0	-0.04
	NOV	1003	1053	1039	-14	-1.36	1039	-14	-1.36
	DEC	854	908	895	-13	-1.47	895	-13	-1.47
	JAN	816	890	878	-12	-1.39	878	-12	-1.39
	FEB	786	770	768	-2	-0.21	768	-2	-0.23
	MAR	630	624	624	0	0.00	624	0	0.00
1977	APR	1123	1090	1097	6	0.59	1097	6	0.59
	MAY	1437	1473	1481	7	0.49	1481	7	0.49
	JUN	1631	1627	1630	3	0.20	1630	3	0.20
	JUL	1311	1360	1369	9	0.68	1369	9	0.69
	AUG	1371	1433	1442	9	0.63	1442	9	0.62
	SEPT	1232	1278	1286	8	0.64	1286	8	0.64

Muddy Creek Reservoir Analysis -- Colorado River At Dotsero Gage

Water Year	Month	Historic Dotsero Flows (cfs)	Simulate Base Flows (cfs)	West Slope Sales: Simulated Project Flows (cfs)	West Slope Sales: Change In Flows (cfs)	West Slope Sales: Percent Change	Metro Denver Lease: Simulated Project Flows (cfs)	Metro Denver Lease: Change In Flows (cfs)	Metro Denver Lease: Percent Change
		1	2	3	4	5	6	7	8
	OCT	960	1045	1050	5	0.46	1051	6	0.59
	NOV	677	719	717	-2	-0.23	721	3	0.37
	DEC	726	765	764	-1	-0.18	767	2	0.28
	JAN	758	722	722	0	-0.05	706	-17	-2.30
	FEB	745	674	673	0	-0.04	664	-10	-1.50
	MAR	810	795	795	0	-0.03	787	-8	-1.06
1978	APR	1604	1525	1535	10	0.68	1517	-8	-0.50
	MAY	4178	3585	3185	-399	-11.14	3183	-402	-11.22
	JUN	7488	6901	6887	-14	-0.20	6530	-371	-5.38
	JUL	3075	2492	2476	-15	-0.62	2492	0	0.00
	AUG	1428	1416	1425	9	0.63	1425	9	0.63
	SEPT	1331	1243	1243	0	0.00	1243	0	0.00
	OCT	1216	1256	1257	0	0.03	1257	0	0.01
	NOV	1223	1222	1209	-13	-1.07	1209	-13	-1.07
	DEC	814	838	826	-12	-1.44	826	-12	-1.44
	JAN	755	788	777	-11	-1.40	777	-11	-1.40
	FEB	822	851	844	-7	-0.80	844	-7	-0.80
	MAR	906	925	922	-3	-0.32	922	-3	-0.32
1979	APR	1422	1527	1529	3	0.16	1529	2	0.15
	MAY	5412	4825	4695	-130	-2.70	4668	-157	-3.26
	JUN	7841	7019	7001	-18	-0.26	7014	-5	-0.06
	JUL	4415	3387	3375	-12	-0.35	3391	4	0.11
	AUG	1652	1541	1635	94	6.12	1635	94	6.12
	SEPT	1300	1101	1101	0	0.00	1101	0	0.01
	OCT	1249	1136	1130	-7	-0.60	1130	-7	-0.60
	NOV	1108	1171	1144	-27	-2.30	1144	-27	-2.31
	DEC	1081	1169	1143	-26	-2.21	1142	-26	-2.23
	JAN	1021	1122	1098	-25	-2.22	1098	-25	-2.22
	FEB	1026	1106	1085	-21	-1.89	1085	-21	-1.89
	MAR	1020	913	906	-7	-0.77	906	-7	-0.77
1980	APR	1645	1326	1323	-3	-0.20	1323	-3	-0.19
	MAY	5682	4429	4296	-134	-3.02	4306	-123	-2.78
	JUN	7134	5631	5607	-25	-0.44	5620	-11	-0.20
	JUL	2462	2228	2216	-12	-0.53	2231	4	0.16
	AUG	1433	1135	1144	9	0.79	1144	9	0.79
	SEPT	1341	1136	1144	8	0.72	1144	8	0.72
	OCT	1053	1099	1099	0	-0.03	1099	0	-0.03
	NOV	981	1048	1033	-14	-1.38	1033	-14	-1.38
	DEC	921	984	970	-14	-1.37	970	-14	-1.37
	JAN	753	873	860	-13	-1.43	860	-13	-1.43
	FEB	663	678	676	-2	-0.27	677	-2	-0.24
	MAR	668	656	656	0	0.00	656	0	0.00
1981	APR	1097	1191	1198	6	0.54	1198	6	0.54
	MAY	1735	1739	1635	-105	-6.01	1633	-106	-6.09
	JUN	2553	2566	2544	-22	-0.84	2524	-42	-1.63
	JUL	1352	1333	1342	9	0.70	1342	9	0.70
	AUG	1336	1415	1424	9	0.63	1424	9	0.62
	SEPT	1305	1225	1234	8	0.67	1234	8	0.67

Muddy Creek Reservoir Analysis -- Colorado River At Dotsero Gage

Water Year	Month	Historic Dotsero Flows (cfs)	Simulate Base Flows (cfs)	¦--- West Slope Sales --¦ Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change	¦--Metro Denver Lease--¦ Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change
		1	2	3	4	5	6	7	8
	OCT	1037	1003	1007	3	0.34	1007	3	0.34
	NOV	849	881	861	-20	-2.25	861	-20	-2.23
	DEC	726	791	770	-20	-2.55	770	-20	-2.55
	JAN	739	769	750	-19	-2.50	750	-19	-2.50
	FEB	741	762	747	-15	-1.98	747	-15	-1.96
	MAR	858	831	826	-5	-0.65	826	-5	-0.63
1982	APR	1257	1209	1213	4	0.32	1213	4	0.32
	MAY	3412	3148	3010	-138	-4.38	2891	-257	-8.17
	JUN	5833	5153	5139	-14	-0.26	5077	-76	-1.48
	JUL	3584	3239	3205	-34	-1.05	3221	-19	-0.57
	AUG	2056	1813	1792	-21	-1.17	1807	-6	-0.31
	SEPT	1551	1452	1447	-5	-0.37	1455	3	0.20

TABLE A.7

Muddy Creek Reservoir Analysis--Colorado River at Kremmling Gage

Metro Denver Lease and West Slope Sales

Summary Table

Muddy Creek Reservoir Analysis -- Colorado River At Kremmling Gage

Water Year	Month	Historic Kremmlin Flows (cfs)	Simulate Base Flows (cfs)	Simulated Project Flows (cfs)	West Slope Sales: Change In Flows (cfs)	West Slope Sales: Percent Change	Metro Denver Lease: Simulated Project Flows (cfs)	Metro Denver Lease: Change In Flows (cfs)	Metro Denver Lease: Percent Change
		1	2	3	4	5	6	7	8
	OCT	1005	849	844	-6	-0.69	849	0	0.00
	NOV	754	819	826	7	0.86	819	0	0.02
	DEC	842	794	801	7	0.86	794	0	0.00
	JAN	909	816	823	7	0.84	816	0	0.00
	FEB	1025	822	823	1	0.09	822	0	0.00
	MAR	1394	842	842	1	0.06	842	0	-0.02
1962	APR	3297	2491	2417	-74	-2.96	2421	-71	-2.83
	MAY	4232	2346	2333	-13	-0.56	2341	-5	-0.20
	JUN	2472	1561	1547	-14	-0.93	1559	-3	-0.17
	JUL	2304	1848	1837	-11	-0.58	1850	3	0.14
	AUG	1011	826	842	17	2.02	840	15	1.77
	SEPT	762	575	589	14	2.37	587	12	2.05
	OCT	1413	572	574	2	0.44	573	2	0.28
	NOV	1017	591	593	2	0.31	586	-5	-0.88
	DEC	669	572	574	2	0.31	567	-5	-0.91
	JAN	522	688	690	2	0.23	683	-5	-0.76
	FEB	503	573	575	2	0.35	574	1	0.22
	MAR	564	616	618	2	0.35	617	1	0.24
1963	APR	613	725	733	8	1.15	733	7	1.02
	MAY	695	464	342	-121	-26.14	355	-109	-23.51
	JUN	466	441	430	-12	-2.67	441	0	0.00
	JUL	539	637	639	2	0.32	637	0	0.00
	AUG	630	954	971	17	1.75	969	15	1.53
	SEPT	757	698	711	14	1.95	709	12	1.69
	OCT	641	744	747	2	0.31	660	-84	-11.30
	NOV	442	521	523	1	0.26	516	-6	-1.10
	DEC	277	453	454	1	0.21	447	-6	-1.29
	JAN	278	456	457	1	0.21	450	-6	-1.28
	FEB	305	334	336	2	0.55	335	1	0.32
	MAR	336	313	316	2	0.69	315	1	0.47
1964	APR	536	528	537	8	1.57	536	8	1.43
	MAY	1032	594	457	-137	-23.00	406	-188	-31.62
	JUN	765	531	519	-12	-2.22	434	-96	-18.18
	JUL	565	415	417	2	0.50	415	0	0.00
	AUG	819	622	638	17	2.69	636	15	2.36
	SEPT	889	728	742	14	1.87	686	-42	-5.75
	OCT	654	642	644	2	0.34	643	1	0.18
	NOV	399	490	491	1	0.24	484	-6	-1.16
	DEC	411	458	459	1	0.21	453	-6	-1.28
	JAN	416	465	466	1	0.21	459	-6	-1.26
	FEB	390	450	445	-5	-1.11	445	-6	-1.28
	MAR	388	442	441	-1	-0.29	440	-2	-0.44
1965	APR	967	785	783	-2	-0.25	782	-3	-0.36
	MAY	1647	1035	899	-137	-13.20	889	-146	-14.12
	JUN	1875	1447	1430	-17	-1.18	1442	-5	-0.37
	JUL	1558	916	904	-12	-1.29	917	2	0.18
	AUG	1485	1106	1093	-13	-1.21	1106	0	0.00
	SEPT	770	656	670	14	2.07	668	12	1.79

Muddy Creek Reservoir Analysis -- Colorado River At Kremmling Gage

			¦--- West Slope Sales --¦				--Metro Denver Lease--¦		
Water Year	Month	Historic Kremmlin Flows (cfs)	Simulate Base Flows (cfs)	Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change	Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change
		1	2	3	4	5	6	7	8
	OCT	762	766	769	4	0.50	768	3	0.36
	NOV	837	886	890	4	0.49	883	-3	-0.28
	DEC	904	841	846	4	0.50	839	-3	-0.31
	JAN	846	822	826	4	0.51	820	-3	-0.32
	FEB	853	653	656	3	0.39	655	2	0.28
	MAR	956	707	710	2	0.30	709	1	0.21
1966	APR	617	575	584	8	1.44	583	7	1.28
	MAY	720	382	277	-104	-27.29	286	-96	-25.09
	JUN	379	363	365	2	0.51	363	0	0.00
	JUL	795	539	541	2	0.38	539	0	0.00
	AUG	787	682	699	17	2.45	697	15	2.15
	SEPT	843	926	940	14	1.47	938	12	1.27
	OCT	631	615	617	2	0.38	616	1	0.21
	NOV	432	450	451	1	0.30	444	-6	-1.27
	DEC	381	395	396	1	0.24	389	-6	-1.48
	JAN	420	388	389	1	0.25	382	-6	-1.51
	FEB	448	329	331	2	0.62	330	1	0.38
	MAR	589	484	486	2	0.45	485	1	0.30
1967	APR	838	756	764	8	1.10	763	7	0.98
	MAY	863	481	331	-149	-31.07	345	-136	-28.30
	JUN	1048	453	439	-14	-3.06	453	0	0.00
	JUL	849	552	539	-13	-2.43	552	0	0.00
	AUG	862	777	794	17	2.15	792	15	1.88
	SEPT	755	697	711	14	1.95	709	12	1.69
	OCT	604	631	631	1	0.09	630	0	-0.08
	NOV	558	623	621	-2	-0.35	614	-9	-1.46
	DEC	518	626	628	2	0.34	621	-5	-0.75
	JAN	534	653	655	2	0.32	648	-5	-0.72
	FEB	552	508	511	2	0.43	510	1	0.28
	MAR	546	416	418	2	0.52	417	1	0.35
1968	APR	938	512	520	8	1.63	519	7	1.44
	MAY	951	812	691	-121	-14.91	680	-133	-16.32
	JUN	1314	633	621	-12	-1.86	633	0	0.00
	JUL	922	525	512	-13	-2.55	525	0	0.00
	AUG	1049	679	645	-34	-5.04	658	-21	-3.07
	SEPT	804	692	705	14	1.97	703	12	1.70
	OCT	748	684	688	4	0.58	687	3	0.41
	NOV	628	724	728	5	0.63	721	-3	-0.35
	DEC	593	671	675	4	0.63	669	-3	-0.39
	JAN	586	674	678	4	0.63	671	-3	-0.41
	FEB	580	663	662	-2	-0.27	661	-3	-0.41
	MAR	584	434	433	0	-0.07	433	-1	-0.23
1969	APR	943	729	635	-93	-12.82	628	-101	-13.84
	MAY	1176	581	573	-8	-1.44	581	0	0.00
	JUN	1961	828	816	-12	-1.42	828	0	0.00
	JUL	1545	671	649	-22	-3.33	662	-9	-1.33
	AUG	883	806	822	17	2.07	820	15	1.82
	SEPT	733	698	712	14	1.95	710	12	1.68

Muddy Creek Reservoir Analysis -- Colorado River At Kremmling Gage

Water Year	Month	Historic Kremmlin Flows (cfs)	Simulate Base Flows (cfs)	Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change	Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change
				¦--- West Slope Sales	--	¦	--Metro Denver Lease	--¦	
		1	2	3	4	5	6	7	8
	OCT	732	795	798	2	0.31	797	1	0.18
	NOV	736	751	753	2	0.27	745	-5	-0.67
	DEC	745	833	834	2	0.20	827	-5	-0.62
	JAN	627	721	722	2	0.22	716	-5	-0.72
	FEB	695	689	684	-4	-0.65	683	-5	-0.76
	MAR	778	582	581	-1	-0.19	580	-2	-0.31
1970	APR	1036	906	896	-10	-1.10	895	-11	-1.21
	MAY	4014	2424	2271	-153	-6.30	2190	-234	-9.66
	JUN	3615	1640	1597	-43	-2.64	1609	-32	-1.93
	JUL	1505	1122	1178	56	4.96	1191	69	6.16
	AUG	1088	649	649	0	-0.01	646	-2	-0.32
	SEPT	770	680	682	2	0.27	680	0	0.00
	OCT	834	788	793	5	0.63	792	4	0.47
	NOV	800	892	898	6	0.72	891	-1	-0.07
	DEC	644	713	719	6	0.87	712	-1	-0.11
	JAN	642	707	713	6	0.87	706	-1	-0.09
	FEB	740	715	715	0	0.01	714	-1	-0.10
	MAR	896	717	717	0	0.03	716	0	-0.07
1971	APR	1543	1118	1007	-111	-9.92	992	-127	-11.34
	MAY	2882	1798	1786	-11	-0.64	1745	-53	-2.93
	JUN	3763	2556	2541	-15	-0.58	2553	-3	-0.12
	JUL	2290	1252	1242	-10	-0.79	1255	4	0.29
	AUG	1055	588	587	-1	-0.12	585	-3	-0.47
	SEPT	810	658	660	2	0.28	658	0	0.00
	OCT	727	678	683	5	0.70	682	4	0.57
	NOV	761	826	832	6	0.75	825	-1	-0.10
	DEC	620	706	712	6	0.85	705	-1	-0.11
	JAN	567	655	661	6	0.92	654	-1	-0.12
	FEB	619	693	693	0	0.01	692	-1	-0.10
	MAR	845	661	661	0	0.03	660	-1	-0.10
1972	APR	993	680	687	7	1.10	686	6	0.94
	MAY	1659	777	656	-121	-15.59	667	-110	-14.17
	JUN	2047	757	745	-12	-1.55	757	0	0.00
	JUL	1011	682	677	-5	-0.70	675	-7	-1.00
	AUG	930	828	845	17	2.01	843	15	1.77
	SEPT	755	719	732	14	1.89	731	12	1.64
	OCT	655	641	643	2	0.39	642	1	0.23
	NOV	759	804	806	2	0.25	799	-5	-0.65
	DEC	527	624	625	2	0.26	618	-5	-0.83
	JAN	519	605	606	2	0.27	599	-5	-0.89
	FEB	523	606	602	-4	-0.74	601	-5	-0.86
	MAR	541	473	472	-1	-0.27	471	-2	-0.41
1973	APR	683	609	613	4	0.68	612	3	0.50
	MAY	2394	1444	1303	-142	-9.82	1292	-152	-10.53
	JUN	2872	1674	1657	-17	-1.01	1669	-5	-0.31
	JUL	2913	1869	1859	-10	-0.53	1872	4	0.19
	AUG	1201	849	833	-16	-1.83	846	-3	-0.36
	SEPT	854	702	704	2	0.26	702	0	0.00

Muddy Creek Reservoir Analysis -- Colorado River At Kremmling Gage

Water Year	Month	Historic Kremmlin Flows (cfs)	Simulate Base Flows (cfs)	West Slope Sales: Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change	Metro Denver Lease: Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change
		1	2	3	4	5	6	7	8
	OCT	903	738	742	5	0.67	741	4	0.53
	NOV	835	785	792	6	0.81	785	-1	-0.09
	DEC	611	695	701	6	0.87	694	-1	-0.12
	JAN	596	699	705	6	0.86	698	-1	-0.12
	FEB	591	683	683	0	0.01	682	-1	-0.11
	MAR	887	733	733	0	0.03	732	-1	-0.09
1974	APR	1187	961	967	6	0.60	965	5	0.49
	MAY	3527	2371	2260	-111	-4.68	2271	-100	-4.23
	JUN	3289	1879	1864	-15	-0.79	1876	-3	-0.16
	JUL	1555	1102	1092	-10	-0.89	1106	4	0.32
	AUG	1007	586	600	15	2.49	598	13	2.14
	SEPT	996	621	623	2	0.30	621	0	0.00
	OCT	790	794	797	4	0.46	796	3	0.33
	NOV	631	768	772	4	0.52	765	-3	-0.39
	DEC	521	658	662	4	0.59	656	-3	-0.44
	JAN	513	650	654	4	0.60	647	-3	-0.45
	FEB	536	676	673	-2	-0.31	673	-3	-0.43
	MAR	562	532	532	0	-0.08	531	-1	-0.21
1975	APR	899	611	615	5	0.78	615	4	0.66
	MAY	1523	929	804	-125	-13.49	825	-105	-11.27
	JUN	1825	1092	1076	-16	-1.46	1087	-4	-0.38
	JUL	1591	1053	1043	-10	-0.93	1056	4	0.34
	AUG	1103	728	727	0	-0.03	725	-2	-0.34
	SEPT	862	670	683	14	2.03	682	12	1.76
	OCT	768	631	634	4	0.63	633	3	0.46
	NOV	701	822	827	4	0.53	820	-3	-0.31
	DEC	575	705	709	4	0.58	702	-3	-0.39
	JAN	563	693	697	4	0.59	690	-3	-0.40
	FEB	598	695	693	-2	-0.25	692	-3	-0.36
	MAR	799	543	542	0	-0.05	542	-1	-0.21
1976	APR	782	616	623	7	1.16	622	6	1.01
	MAY	1292	761	640	-121	-15.92	639	-121	-15.97
	JUN	1179	627	615	-12	-1.88	627	0	0.00
	JUL	662	546	524	-22	-4.06	538	-9	-1.61
	AUG	805	813	830	17	2.05	828	15	1.80
	SEPT	845	663	676	14	2.05	675	12	1.78
	OCT	653	668	670	2	0.37	669	1	0.22
	NOV	585	643	645	2	0.31	638	-5	-0.78
	DEC	573	635	636	2	0.26	629	-5	-0.82
	JAN	488	569	571	2	0.28	564	-5	-0.92
	FEB	440	426	429	2	0.52	428	1	0.29
	MAR	331	326	328	2	0.66	328	1	0.45
1977	APR	639	607	615	8	1.37	614	7	1.22
	MAY	477	512	522	10	1.98	521	9	1.72
	JUN	519	508	513	5	0.99	511	3	0.63
	JUL	923	975	993	18	1.85	991	16	1.65
	AUG	1031	1099	1115	17	1.52	1113	15	1.33
	SEPT	923	973	986	13	1.38	984	12	1.21

Muddy Creek Reservoir Analysis -- Colorado River At Kremmling Gage

Water Year	Month	Historic Kremmlin Flows (cfs)	Simulate Base Flows (cfs)	¦--- West Slope Sales --¦ Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change	¦--Metro Denver Lease--¦ Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change
		1	2	3	4	5	6	7	8
	OCT	556	643	650	7	1.15	651	8	1.27
	NOV	352	400	417	17	4.24	414	14	3.61
	DEC	363	407	423	16	3.84	420	13	3.08
	JAN	424	393	408	15	3.93	385	-7	-1.91
	FEB	452	382	387	4	1.09	376	-6	-1.60
	MAR	465	452	454	2	0.48	445	-7	-1.48
1978	APR	774	695	708	13	1.80	689	-6	-0.92
	MAY	1750	1153	755	-398	-34.51	751	-402	-34.87
	JUN	1970	1374	1363	-12	-0.86	1003	-371	-27.00
	JUL	1138	551	538	-13	-2.43	551	0	0.00
	AUG	835	828	845	17	2.01	843	15	1.77
	SEPT	896	807	809	2	0.23	807	0	0.00
	OCT	746	789	793	3	0.42	791	2	0.27
	NOV	740	747	750	3	0.43	743	-4	-0.52
	DEC	525	557	560	3	0.52	553	-4	-0.70
	JAN	514	554	557	3	0.53	550	-4	-0.70
	FEB	509	540	537	-3	-0.56	537	-4	-0.70
	MAR	462	482	481	-1	-0.16	481	-1	-0.30
1979	APR	725	830	835	5	0.56	884	54	6.50
	MAY	2139	1547	1419	-129	-8.32	1390	-157	-10.15
	JUN	2443	1613	1597	-16	-1.01	1609	-5	-0.28
	JUL	2113	1082	1072	-10	-0.91	1085	4	0.33
	AUG	948	842	944	102	12.12	942	100	11.87
	SEPT	826	627	629	2	0.29	628	0	0.03
	OCT	775	664	660	-4	-0.58	659	-5	-0.73
	NOV	592	663	653	-11	-1.60	646	-18	-2.69
	DEC	573	669	658	-11	-1.63	651	-18	-2.67
	JAN	522	631	620	-11	-1.73	613	-18	-2.81
	FEB	534	617	600	-17	-2.77	599	-18	-2.89
	MAR	568	462	457	-5	-1.05	456	-6	-1.20
1980	APR	1028	710	709	-1	-0.11	709	-2	-0.21
	MAY	2869	1612	1480	-132	-8.20	1489	-123	-7.65
	JUN	2643	1133	1110	-23	-2.02	1122	-11	-0.98
	JUL	1191	954	944	-10	-1.03	957	4	0.37
	AUG	930	637	654	17	2.62	652	15	2.30
	SEPT	802	600	614	14	2.27	612	12	1.96
	OCT	591	640	642	3	0.41	641	2	0.25
	NOV	525	600	602	2	0.31	595	-5	-0.87
	DEC	498	568	570	1	0.26	563	-5	-0.95
	JAN	401	527	528	1	0.28	521	-5	-1.02
	FEB	353	371	373	2	0.55	372	1	0.39
	MAR	372	361	363	2	0.60	362	1	0.40
1981	APR	558	654	662	8	1.27	661	7	1.13
	MAY	659	661	559	-102	-15.36	557	-104	-15.77
	JUN	564	569	550	-20	-3.47	527	-42	-7.36
	JUL	602	587	605	18	3.07	603	16	2.72
	AUG	972	1056	1073	17	1.58	1071	14	1.37
	SEPT	842	766	779	14	1.78	777	12	1.54

Muddy Creek Reservoir Analysis -- Colorado River At Kremmling Gage

Water Year	Month	Historic Kremmlin Flows (cfs)	Simulate Base Flows (cfs)	¦--- West Slope Sales --¦ Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change	¦--Metro Denver Lease--¦ Simulated Project Flows (cfs)	Change In Flows (cfs)	Percent Change
		1	2	3	4	5	6	7	8
	OCT	576	543	550	6	1.18	549	5	0.99
	NOV	455	494	491	-4	-0.72	484	-10	-2.11
	DEC	376	448	443	-5	-1.16	436	-12	-2.68
	JAN	451	488	482	-5	-1.07	476	-12	-2.47
	FEB	429	452	441	-11	-2.50	441	-12	-2.63
	MAR	403	378	375	-3	-0.85	374	-4	-0.99
1982	APR	573	527	532	6	1.10	531	5	0.93
	MAY	1113	846	709	-137	-16.16	588	-257	-30.41
	JUN	1592	904	892	-12	-1.30	828	-76	-8.42
	JUL	1221	873	841	-32	-3.66	855	-19	-2.12
	AUG	1133	896	882	-13	-1.50	896	0	0.00
	SEPT	841	746	746	0	0.00	752	6	0.86

APPENDIX B--BENEFIT/COST ANALYSIS

APPENDIX B

BENEFIT/COST ANALYSIS

ROCK CREEK AND MUDDY CREEK RESERVOIRS

As required by the U.S. Forest Service, a benefit/cost (B/C) analysis was completed for Rock Creek and Muddy Creek reservoirs. Note that the construction of either of these reservoirs is somewhat unique relative to the usual B/C study in that the reason for the development of storage is to compensate the West Slope water users for water which has been or soon will be diverted to the East Slope of the Rocky Mountains. As such, the justification for the added storage is based on water consumption and value on the East Slope. An agreement between the River District and the Denver Water Board has set the sale price at $250 per acre-foot for 25 years.

Applying this value to the 15,000 acre-foot sales from either Rock Creek or Muddy Creek reservoirs results in an annual sales value of $3,750,000. The Forest Service recognizes present net value (PNV) as the appropriate benefit/cost analysis measure. Even with high rates of discount, such as a 7.75 percent rate, suggested by the Water Resources Council, this yields a present net value of $42,025,000.

The other major economic benefit of either reservoir is the reservoir recreation that would be generated. Based on a 1986 recreation demand study for Rock Creek and Muddy Creek reservoirs, Table 4.3.16.1 indicates the projected visitation to the Rock Creek and Muddy Creek sites for various sizes of campsite development. This projected increase in visitation at Rock Creek would amount to $12,900,000 discounted over 25 years and would dominate the loss of benefits from stream fishing, even at the low RPG value, such as $5 to $10 per visitor day. Thus, total recreation value would appear to increase, rather than decrease, as a result of the construction at Rock Creek. Recreation benefits at Muddy Creek would be slightly lower but still substantial at $10,000,000 (Table B1). However, it should be noted that most of the projected visitation would be a result of substituting either site for some other, less desirable, site. The true recreational benefit would be the cost saving from reduced travel distance to equivalent sites, or the improvement on the quality of recreation at

equally distant sites, or both. These values cannot be estimated given the data available. However, it is likely that the benefits to reservoir recreators would be in the same range as the benefit to stream recreators displaced. It is also likely that stream recreation sites will become more scarce in the future relative to reservoir sites, so that the loss of stream fisheries may be increasing in value relative to reservoir recreation.

Table B1 summarizes the costs and benefits of the two projects. Construction costs were derived from Table 2.6.2 and include mitigation costs. Annual operation and maintenance costs include $80,000 for each reservoir, $10,000 for fish stocking, $10,000 for the Forest Service permit at Rock Creek, and $10,000 for shoreline maintenance at Muddy Creek. The other cost of the project is current recreation value that would be lost. Current recreation visitation at the Rock Creek site (Shoe and Stocking Creek campground) is significant, but relatively small. Current data would suggest no more than an average of about 80 visitor-days per weekend or holiday, and about half that amount of visitation during each week. Thus, a summer visitation total would be approximately 2,000 visitor-days. This site produces a quality stream fishing area which has a limited number of substitutes. Therefore, a benefit per visitor-day (taken from the Resource Planning Guide [RPG] values used in Forest Service Planning Guides which are based on consumers' surplus measures of benefit, not local expenditures) of from $25 to $50 could be expected. Given the distibution of visitors and the distance traveled, this range of values would probably bracket a travel cost based estimate of consumers' surplus (value) per visitor day. The loss of this fishery would result in a maximum loss of about $100,000 in annual recreation value, which is relatively insignificant. Discounted over 25 years this value is $1,500,000 as shown in Table B1. Very little present recreation occurs at Muddy creek so the loss is quite small (Table B1).

Given the projected cost of construction plus the present value of operation and maintenance costs and the cost of lost recreation, projected cost is $20,499,000 for Rock Creek Reservoir and $21,178,800 for Muddy Creek Reservoir. The benefit/cost ratio for the dams is 2.7 and 2.5 for Rock Creek and Muddy Creek, respectively (Table B1). The sale of water to the Denver Water Board can be renewed for an additional 25 years if no demand for the water is forthcoming from the West Slope.

Table B1
Present Net Value and Benefit/Cost Analysis
(Millions of 1980 dollars) 1/

Site	Cost: Construction 2/	Cost: Op. and maint.	Recreation	Benefit: Water sales	Benefit: Reservoir recreation 3/	PNV	B/C
Rock Creek	17.909	1.09 4/	1.50	42.025	12.900	34.426	2.7
Muddy Creek	19.458	1.09	0.13	42.025	10.000	30.847	2.5

1/ The Forest Service recognizes Present Net Value as the appropriate efficiency criterion for project analysis.

2/ Includes the purchase of private ground, assumed to be valued at the present value of future net earnings in present use.

3/ Assumes approximately 200,000 visitor days annually for Rock Creek and 175,000 visitors annually for Muddy Creek at $5.00 per visitor day.

4/ Includes a $10,000 annual easement charge by the U.S. Forest Service.

Either dam project would have a very positive value for the first 25 years due to the lease with Denver, 2.7 and 2.6 for Rock Creek and Muddy Creek, respectively. The present net value of water sales for West Slope irrigation for 25-50 years after dam completion would be $1,152,000 using the RPA value of irrigation water at $45.50 per acre-foot. At this point in time the dam construction costs would have been repaid and only operation costs would need to be covered for a positive benefit/cost value. Note also that, insofar as Federal public money is concerned, there is no construction cost involved. That is, a private agreement for the provision of construction funds has been established, as well as State of Colorado funds; the economic security of the project is not a significant question.

Other problems, such as a loss of grazing areas and big game herds would be mitigated, and the costs of mitigation are included in cost of construction for both dams.

A significant industry has developed around floating the Colorado River and its tributaries. Neither Rock nor Muddy Creek sales would dewater the Blue and Colorado rivers by a significant amount (more than 5

percent). However, given the withdrawals of water already controlled by East Slope water agencies, the flow in these rivers would be reduced below the minimum required to maintain a viable floating environment. Thus, the reservoirs would not have a significant economic impact on the region.

An analysis of costs and benefits of the two proposed alternative reservoir sites (Rock Creek and Muddy Creek) was made that included the PNV of the site that would not be constructed. For example, as shown in Table B2, if Rock Creek were built, the PNV of the land at the Muddy Creek site would remain and could be added to the benefits that would accrue over the construction costs at Rock Creek. The PNV of Muddy Creek lands would be their predicted present value, judged to be $1,000/acre by the River District in this DEIS. With 1,600 acres planned for purchase, the PNV would be $1.6 million. If the Muddy Creek site were built, the PNV of the Rock Creek site would include values for recreation, grazing, and private land that would be purchased (Table B2). Therefore, the total PNV values for both sites are very similar at $36,026,000 and $32,466,000 for Rock Creek and Muddy Creek, respectively.

Table B2
Present Net Value Analysis for Alternative Programs

Site	Direct costs	Direct benefits	Alternative site benefit 1/	PNV
Rock Creek	20.499	54.925	1.600 2/	36.026
Muddy Creek	21.178	52.025	1.500 3/ 0.019 4/ 0.100 5/	32.466

1/ Current benefits to the site not used.

2/ Land value of Muddy Creek, assuming that the sale value reflects the present net value of future net earnings.

3/ Present net value of stream recreation on Rock Creek.

4/ Present net value of 250 AUMs of pasture in Rock Creek using RPA value of $6.00.

5/ Present net value of 100 acres of private land at $1,000/acre.

APPENDIX C

SOIL AND WATER MITIGATION AND MONITORING PLAN

APPENDIX C

SOIL AND WATER MITIGATION AND MONITORING PLAN

I. INTRODUCTION

The following mitigation plan was developed to address adverse impacts to the soil resource incurred through implementation of the proposed project, and to protect water quality and channel stability. Project activities addressed through this plan include: road construction, construction of recreation facilities, transmission lines, reservoir, staging, and borrow areas.

The mitigation plan contains specific measures for minimizing, reducing or eliminating the nature and degree of specific impacts which may occur through implementation of the proposed project. The mitigation measures are designed for practical application on-the-ground. They are not tied to site-specific locations at this time. As project design is completed and <u>prior</u> to construction activities, a detailed Erosion Control and Water Quality Monitoring Plan, hereafter called Erosion Control Plan, will be developed by the proponent which includes site-specific location of all mitigation measures. The Plan will be approved by the Forest Service before project implementation begins.

Mitigation is required by the United States Forest Service, for impacts on National Forest System Lands. Therefore, the mitigation plan will outline Forest Service authority and responsibility and the proponent's authority and responsibility for implementation of mitigation plan, and monitoring of construction activities and mitigation measures.

II. ADMINISTRATION

Forest Service involvement with the proposed project extends from the planning stages through the construction period. The mitigation plan will specify the Forest Service involvement throughout the construction of this proposed project.

Prior to beginning of construction activities, an Erosion Control Plan will be developed. This plan will be approved by the U. S. Forest Service and jointly administered by the Forest Service and the proponent. As a provision of this plan, a working agreement will be established which outlines responsibility and authority between the Forest Service and the proponent. The Forest Service shall appoint a representative to ascertain whether all items are completed as specified in the Erosion Control Plan. The proponent shall also appoint a single representative who will work with the F.S. liaison, and who has authority over construction activities. Both the appointed F.S. liaison and the proponent liaison will have equal authority and power to implement the mitigation measures outlined in the Erosion Control Plan. Both liaisons will enter into an agreement which

outlines the above equality of authority. The agreement will include, but not be limited to, the following conditions.

"Both the Forest Service liaison and the proponent liaison shall have authority to . . . "

1) Update the erosion control plan if the first prescribed measures fail to mitigate adverse resource impacts.

2) Shut down the project if Erosion Control Plan is being violated.

3) Change or cease operations if monitoring shows violation of water quality or soil loss stipulations.

Both representatives must be available full time to fulfill duties as liaison for duration of construction period.

The Forest Service liaison will be selected based on technical expertise and awareness of assessing erosion and water quality problems and assessing effectiveness of mitigation measures on-the-ground.

The proponent liaison must be selected based on technical expertise in construction activities and contract administration. The responsibility for properly implementing the Erosion Control Plan will be part of the contract stipulations.

Any change in either appointed liaison must be approved by the Forest Service official responsible for administration of the special use permit.

As all work will be accomplished to the satisfaction of the U.S.F.S. provisions for failures of mitigation measures will also be included in the mitigation plan.

The proponent will be requested to enter into a collection agreement with the Forest Service to reimburse the government for costs associated with the administration and implementation of the mitigation plan. This request will be a collection agreement submitted by the Forest Service to the Applicant.

III. MITIGATION

It is difficult to develop a complete mitigation plan when the specific details of the project are not known. Mitigation measures that work well in certain locations are not acceptable in others. For example, construction activities near streams require much more stringent erosion control practices than sites located far from streams. Mitigation measures that work well in certain soil types may not work in others. It is for these reasons that the Forest Service will require a site-specific erosion control and water quality plan once the project alternative is selected and the detailed engineering work is completed. The site-specific plan will include some of the following mitigation measures.

A. General Mitigation Measures

The mitigation measures detailed in the following paragraphs are recommended for any disturbed sites. Mitigation measures specific to a certain activity such as road construction will be addressed under that specific activity. These mitigation measures are intended to meet the Forest's standards and guidelines for soils resource management. These standards and guidelines include maintaining soil productivity and minimizing man-caused soil erosion. Soil disturbance caused by human activity will be restored to soil loss tolerance levels commensurate with the natural ecological processes for the treatment area.

1. Clearing. Areas to be cleared for construction activities will have merchantable timber removed unless specified otherwise. Slash along road clearings should be windrowed along the toe of the fill slopes as the road is being constructed. These windrows act as sediment traps and help keep sediment from the roads onsite. Slash piles from other construction areas will be burned at designated burn sites only. These sites will be selected by the F.S. liaison. No slash bill be buried in the fill slopes. Any debris that falls into streams during clearing operations will be removed immediately. Clearings will be kept to the minimum size necessary to accomplish the project. The construction zone will be marked with flagging. Any operator that goes out of the designated zone will be penalized. The penalty will consist of a fine. The minimum fine will be determined by the Forest Service. Larger fines can be assessed if the damage that is done cannot be corrected with the minimum fine. Protection of existing vegetation can save a lot of time and money in revegetation work and it is the Forest Service's intent to protect as much of the existing vegetation as possible.

In sensitive visual areas, and areas proposed for future recreation development, vegetation clearing will be subject to more restrictive standards based on recommendations of the Forest Landscape Architect.

2. Temporary Erosion Control. Erosion control measures must be anticipated and used during the actual construction period. These measures are temporary in nature and are designed to be removed once the construction is complete. They are extremely critical since the potential for water quality and erosion problems are most severe during and directly following construction. Temporary methods include sediment basins, sediment traps, and clear water diversions.

a. Sediment Basins. A sediment basin is a natural or man-made depression used to retain turbid construction water runoff. Temporary basins remain in place for the entire duration of the construction project or until the need for them has clearly passed. Their locations are usually shown on plans, and they are built to a higher standard than sediment traps. Temporary basins will not be constructed in defined drainages. Water entering the basin is slowed, allowing particulates to settle out before passing to downstream areas. The cleaner surface water is drained from the top of the basin, usually through a culvert or a rigid hose. Spillways are provided to protect the basin in the event their capacities are exceeded during storm periods. The size and amount of particulates

retained in a basin are a function of the volume of the inflow water with respect to the size of the basin.

Generally, given a steady inflow the larger the basin, the more sediment will be trapped.

Sediment basins are constructed by building a low head dam, excavating a depression, using a natural depression or any combination of the three. The effectiveness of the basins depend largely upon the selected design, overflow drainage, and maintenance of the structures.

b. Sediment Traps. Sediment traps are also called expedient basins. They are quite small and only exist for a short time (possibly only one night). Their locations are determined in the field as the need arises. Sediment traps operate on the same principle as sediment basins. The traps slow the velocity of runoff water, allowing the coarser particulates to settle and become filtered out. The cleaner surface water is passed on to downstream areas. Sediment traps cannot handle as large runoff volumes as sediment basins can, but they are much easier and quicker to construct. The accumulated sediment and the traps are removed following the construction period.

They can be constructed from a variety of materials, including straw bales, plastic, sand bags, filter cloth, and rocks. Straw bales are perhaps the quickest and easiest sediment trap to construct. Readily available and easy to transport, the bales can be formed into a sediment trap just about anywhere. They must be firmly anchored in the ground to prevent failure underneath or between the bales. The standard procedure is to key them into the ground 4 to 6 inches and to drive steel "re-bar" through the center. Anchoring the bales properly is extremely important in a mountain environment where steep gradients promote high runoff velocities. Straw bales lined with plastic are particularly effective sediment traps, especially if the bales are stacked on top of each other. The plastic prevents turbid water from seeping between or underneath the bales and keeps them drier prolonging their strength.

Another effective and easily transported sediment trap is constructed with the use of a fabric filter. The fabric is made from filament fibers with randomly distributed pore openings. Water easily passes through the fabric, but soil is trapped. The fabric is attached to a temporary wire fence. The bottom 6 inches of the fabric is buried in the ground to prevent water from flowing under the structure. Construction runoff water is directed to the filter trap along berms, dikes, plastic-lined ditches, or culverts. For the best results, the water should be dispersed before encountering the filter blanket. Avoid locating the fences in steep narrow drainages. The fabric has little lateral support and cannot withstand a great force such as that caused by impounding 2 to 3 feet of water.

Sandbags are also effective in trapping sediment. They are considerably heavier and harder to transport than straw bales, but are more durable. They work well when encountering high runoff velocities. Although sandbags are heavy, they are pliable, allowing them to be placed on steep sideslopes and across ground surface irregularities. Because of their weight, sandbags can withstand a greater force per unit area than straw or fabric. This allows more water to be impounded with less risk of failure. The inspection and maintenance of the structures should be performed regularly by the contractor. This should be part of the erosion water quality plan to ensure its enforcement.

All sediment basins and traps must be maintained during the construction period. If the sediment traps fill up before the construction is completed, then the traps must be cleaned out. Sediment from these traps must be disposed of in approved areas. Sediment traps and sediment basins will not be allowed in stream channels. Disposal areas and sediment trap sites will be designated by the FS liaison. The traps and basins will be revegetated after the construction activity is completed. Every attempt must be made to keep this accumulated sediment from reaching the drainages. Additional information on sediment basins can be found in Design of Sediment Basins, No. 70, from the National Cooperative Highway Research Program, National Academy of Sciences, Washington, DC 20418.

c. Clear Water Diversions. Streams, springs, bogs, and shallow subsurface flows all contribute water to the construction zone. In mountainous terrain these drainage patterns are complex and require an array of techniques to divert clean runoff water around disturbed construction sites. Some of the methods used include shallow interception ditches, hay and plastic-lined ditches, and small collection basins with pipe drains.

Hand dug ditches are superior to backhoe trenches. The ditches are usually constructed on sideslopes during the early construction season when conditions are wet. Backhoes have a difficult time operating in these conditions, often sliding and tearing up the area next to the ditch. They also have a disadvantage in working in and around obstacles such as rocks and trees. Hand dug ditches, on the other hand, create minimum impacts and can be constructed through tight places such as forested hillsides or bogs. All clear water diversions will be lined to safeguard against erosion.

Once the clean water is diverted above the construction sites either by ditches or basins, the water has to be directed safely through the construction zone. The method of transport depends upon the anticipated water volumes, the duration of use, length, and steepness of transport.

Metal culverts 18-24 inches in diameter are the most effective all around method of transporting water through work areas. They can withstand high runoff velocities, transport water great distances, and can be expected to last more than one construction season. A

disadvantage of the metal culvert is the high cost. Some of the flexible down drains and plastic-lined ditches are also reliable water transports provided they do not have to carry large runoff volumes over long distances. These structures are more temporary than the metal pipes and require more maintenance.

Flexible down drains are excellent on short, steep slopes. The flexibility conforms to the water flow, maximizing friction and slowing the water velocities. The drains should be staked to the ground to prevent excessive movement from wind or internal water flow. The movement may cause creases or bends which can fail under force of the drainage water. Flexible drains are temporary drainage measures only. They will not be allowed as permanent drainages.

Discharging the intercepted water below the work area is the final stage of a water interception system. Energy dissipators are required below drains to slow the runoff water to non-erosive velocities. A variety of temporary dissipators can be used including loose rock riprap, straw bales, and silt fences.

Loose rock riprap or a wire and rock mattress placed below a drainage outlet can effectively check erosion and undercutting. Loose riprap should be graded, angular rocks, 4-10 inches in diameter. The rock protection should extend to and around the drain outlets. The riprapped area should be at least 4 feet wide to prevent drainage from circumventing the structure.

When water discharge is temporary due to construction activities, simple and less expensive energy dissipators are adequate. Straw bales keyed into the ground and lined with plastic are commonly used. Maintenance is required to see that high velocities do not tear the plastic and break the straw bales. A silt fence can be placed in a semi-circle behind the straw bales to retain sediment that is picked up during transport. These dissipators work well providing high runoff volumes are not encountered. Energy dissipators below high discharge drains should be made of rock even if they are temporary.

3. Permanent Erosion Control. Permanent erosion control structures are designed to last for the life of the project. Permanent erosion control structures include ditches, sub-surface drains, downspouts, buffer strips, retaining walls, and sediment ponds.

a. Ditches. Ditches are used to convey water across or around construction areas as well as drain construction areas, roads, etc. Permanent ditches must be designed to carry the maximum flow expected. Hay or plastic lined ditches that are used for temporary erosion control would not be suitable as permanent structures. Most ditches would need to be lined with rock, concrete, asphalt, or some other erosion resistant material. On flat gradients, rock-lined ditches underlain with a porous filter blanket have been found effective for transporting water. Gabions underlain with a filter blanket are more effective on steeper slopes.

Road drainage ditches are designed to carry runoff from roads and cut slopes. To insure proper location of drainage facilities, it is important to evaluate surface runoff patterns during the initial road planning phases. Most ditches need to be lined to prevent erosion when the flows exceed the stability of the original ditch material. If ditches are not lined, then more ditch relief culverts would be needed in order to get rid of the water before it has a chance to erode the ditch. Ditch relief culverts must have intakes constructed. Intake boxes may be of concrete, rock, or steel. The grade of the culvert should be at least 2 percent more than that of the ditch line. Ditch relief culverts should be skewed downhill about 30 degrees.

b. Downspouts. Downspouts are flumes, either open or enclosed, that convey water from the outlet of a road surface drainage structure downhill over fill slopes or other unstable areas. Energy dissipators may be needed at the outlets of downspouts. Pollution control is the major concern with ditch draining culverts. Any sediment that moves through the ditch and downspout must be trapped before it reaches the stream course. Buffers should be used to absorb the culvert drainage and pollutant before a stream course is reached.

c. Buffer Strips. Buffer strips are areas of undisturbed ground between the construction activity and the site to be protected. Buffer strips act as filters for sediment caused by bare soil surfaces such as cut-and-fill slopes. They are also important for maintaining riparian wildlife habitat and preventing significant temperature alterations in streams. Minimum widths needed to achieve this protection vary according to the obstructions in the buffer strip, the spacing of these obstructions, relative stability of soils, distances between cross drains, distance of cross drains to the first obstruction, density of cover on the fill slope, and periodic renewal of capacity of obstructions for storing sediment. Additional protective works such as logs and slash can be added to a buffer strip in order to make it a more effective sediment.

Buffer strip widths will be determined for all projects in the site-specific erosion control plan. Roads will be surfaced where locations don not allow for the minimum buffer strip width.

d. Retaining Walls. Retaining walls and cribbing are used to retain slides on the upper side of roads and to support shoulders on excessively steep lower slopes. They are also used to prevent the toe of fill slopes from encroaching into sensitive areas, and to reduce the volume of both cuts and fills. To protect the integrity of the drainages and maintain good water quality, several types of retaining walls can be used. Treated wood crib retaining walls are used on small cut slopes, but the larger retaining walls are primarily precast concrete. Some walls can be designed with benches so that vegetation could be planted on the steps. In addition, the concrete can be dyed to match the color of the native rock and soil of the area. The retaining walls are very effective in reducing the encroachment of fill slopes on live drainages. Short (2-3 ft.) retaining walls placed at the toe of large cut slopes help hold the slope in place so

vegetation can become established. They also prevent the slope from being undercut during maintenance. Areas where retaining walls will be required will be specified in the site-specific erosion control plan.

In visually sensitive road corridors, road cuts will be "layed back" and contoured to provide visual blending with the surrounding area. Rock placement and vegetative plantings will duplicate the natural setting. See the Visuals Mitigation Plan for details.

e. Permanent Sediment Basins. Permanent basins are used to intercept sediment during construction but remain after construction for other uses such as recreation, scenic enhancement, floodwater detention, or ground-water recharge. Design standards for permanent basins are needed, they will be identified in the site-specific erosion control plan.

4. Revegetation. The primary emphasis of the revegetation program is the control of erosion and sediment production by re-establishing a protective vegetative cover as soon as possible. Revegetation consists of one or a combination of the following activities: seeding, fertilizer, mulching, application of protective matting, sod and the planting or transplanting of native trees and shrubs. Many of these techniques are those tested on high elevation Rock Mountain ski areas or on soils similar to those found in the project area.

Revegetation by itself will not stabilize oversteepened slopes with long steep faces or slopes with drainage or seepage problems. Efforts to stabilize such slopes vegetatively without first correcting the problem will result in wasted time and money.

It is essential that revegetation proceed immediately after soil disturbance to take advantage of available soil moisture. Therefore, as soil is disturbed, revegetation should closely follow. No more than 1000 feet of exposed soil per project will be allowed at one time. Since the amount of allowable exposed soil is limited, it is imperative that revegetation practices occur concurrently with construction. The application of the seed, fertilizer, mulch, and netting should occur in sequence and not be drawn out over a long period of time.

In sensitive visual areas (foreground scenes along roads, recreation sites, etc.), additional revegetation techniques such as planting visual screens would be required, as directed in the Visual Mitigation Guidelines.

Revegetation will not be considered acceptable until the revegetated area has a ground cover that is 80 percent of the natural cover. The type of transect methodology that will be required in order to determine the vegetation cover will be specified by the USFS.

a. Topsoil. Due to the coarse textured nature of the soils in the Rock Creek area and their low nutrient and water holding capacities, topsoil should be imported when not available to be

stripped so that it can be used to cover all cut-and-fill slopes. The majority of the top soil to be imported can be collected from bogs and meadows that are within a construction area and stockpiled on deposition areas along the right of way. Soil analysis of the topsoil is necessary to determine if the material has a suitable texture, organic matter, and nutrient content.

The topsoil should be spread 4-6 inches deep over the cut and fill. It is essential that it be applied to a relatively rough slope in order to avoid possible topsoil slumping or sliding as it becomes saturated. A rough slope includes small furrows perpendicular to the slope. Depths in excess of 6" may be subject to sliding.

b. Seedbed Preparation. The top 4-6" should be scarified leaving a friable, moist surface for seeding. Areas that have topsoil applied to not need to be scarified. Scarification allows for more rapid rooting of the grasses. If too long a period elapses between scarification and seeding, a hard surface crust will develop. This limits rooting depth and results in poor plant survival. It is necessary to seed within 24 hours of seed bed preparation.

c. Seeding. Application of the seed can be by hand using broadcast seeders or with seeding equipment like rangeland drills. Rangeland drills and larger broadcast seeders are limited by slope. Steep areas will need to be seeded by hand. Quality control of the seeding operation is extremely important. It is relatively easy to compute the number of seeds per square foot and to check this by the use of gummed paper during the seeding operation. It is critical that the appropriate amount of seed is being applied. Too much seed can be as bad as too little. When germination occurs, an area seeded heavily will come up in large clumps of grass and will compete heavily for moisture resulting in a dwarfed stand of grass or total dieback. Any noxious weeds that occur on revegetated sites will be controlled by the proponent through the use of approved methods. All seed shall conform to the requirements of Federal Specifications JJJ-S-181.

After application, the seed should be covered by one-half to one-quarter inch of soil. This can be done by dragging an implement over the slopes or hand raking smaller areas. Seed not covered with topsoil will germinate on the surface of the ground and die as the soil dries out. Seed that is applied during the dry season may need to be watered in order to get it to germinate. The FS liaison will determine which areas need to be watered in order to insure seed survival. In visually sensitive areas, planting should include a broader variety of "native" plants to avoid contrast with undisturbed areas. See Visuals Mitigation Plan.

d. Fertilizer. Fertilizer is necessary for all plantings. Low nutrient levels along with the short growing season slow soil formation processes, and low decomposition rates, result in extremely harsh conditions for plant growth.

Care must be taken not to over-fertilize since it can result in water quality problems and wasted money. A given soil texture can only hold a certain amount of nutrients. Coarse textured soils hold lower levels of nutrients than fine textured soils or soils with high organic matter content. Therefore, it is appropriate to regulate the amount of fertilizer being applied according to the soil texture and content of organic matter. Fertilizer recommendations should be based on lab analysis.

Maintenance fertilization with nitrogen is necessary to insure an adequate stand of grass. Light green or yellowing color or grass and slow growth or thinning of the stand is a good indicator that fertilization is necessary. Irrigated areas at high elevations require increased fertilizer applications due to the leaching effect of the irrigation and increased vegetation growth requiring more nutrients. Maintenance fertilizer should be applied in the spring of the following growing season.

e. Mulch. Some form of mulch is essential to aid in germination of grass seed. The mulch helps to maintain soil moisture and reduces rapid fluctuations in soil temperature. The mulch also aids in temporarily stabilizing the disturbed soil while vegetation is being established.

There are many types of mulch such as straw, hay, slash, wood chips, etc. Straw and native hay are two of the more popular and least expensive mulching materials. Mulch should be applied at a rate of 1-1/2 - 2 tons per acre. It should not be more than 2 to 3 inches deep in any one spot on the surface. It should be applied by a blower or by hand. It is essential that the mulch be anchored to the ground to prevent its removal by wind, gravity, and water. Methods of anchoring the mulch include: (1) incorporating it into the soil by use of a crimper or modified sheep's foot, (2) spraying with chemical tackifier, or (3) use of a netting.

Erosion control matting can be used on steeper slopes to hold the mulch in place and a crimper can be used on flatter slopes. Chemical tackifiers can be used on any slope.

Several machines are effective for crimping mulch into the ground. When crimping mulch into the soil, the machines work better if the soil is tilled to a depth of 4-6" which is normally done when preparing the seedbed.

f. Erosion Control Matting. On slopes exceeding 2 to 1, some form of matting is needed to hold the soil and mulch in place. There are several types of erosion control material on the market that would be effective in helping to stabilize steep slopes. The matting is expensive but has proven extremely effective in providing an immediate soil erosion protection to sensitive soils. Problems have been found to occur when matting is used on long slopes greater than 2:1. Runoff works its way under the matting and washes it down the slope. The maximum slope lengths for effective use of matting depends on the soil

types and drainage. These slope lengths will be determined once the project alternative has been selected. Slopes exceeding the recommended length will require some other type of mitigation such as terracing to break up slope lengths or use of cribbing or retaining walls.

The matting is very effective in controlling erosion on cut and fill slopes. However, it is important that no concentrated surface runoff be allowed to flow over the slope. Another type of failure which can occur on long slopes is the slumping of soil underneath the matting. This is generally caused by applying topsoil in excess of the recommended depth (4-6").

During installation there should be a 4" overlap on the matting to allow for shrinkage. Also, the matting should be adequately stapled to the ground and tucked into the slope at the upper end. One advantage of the jute matting over several other types of matting on the market is if the initial seeding fails you can reseed over the jute matting while it still provides an erosion control protection. It takes approximately 5 years for the material to decompose at high elevations.

B. <u>Specific Mitigation Measures</u>

Specific measures are those that apply to a certain activity such as roads, reservoirs, staging areas, borrow areas, reservoir operations, etc. The general mitigation measures apply to all types of soil disturbing activities.

1. <u>Roads and Powerline Corridors</u>. Proper route selection is critical in helping to reduce impacts from roads. Roads should be located on ridgetops, benches, or on upper slopes. Ridges usually provide good alignment with little excavation. Drainage is good and fewer culverts are needed. Sensitive areas such as streams and wetlands should be avoided. The prescription for riparian areas in the Forest Plans states that roads and trails will be located outside of riparian areas unless alternative routes have been reviewed and found to be more environmentally damaging. If road construction must take place within wetlands, a permeable fill material or filter fabric will be used for at least the first layer of fill.

Roads that are located on slopes greater than 50 percent will require a full bench and end haul of material to prevent mass wasting and excessive erosion of fill into sensitive and unstable areas. The material will be disposed of at pre-approved disposal sites.

Visual mitigation guidelines should be considered in final road location and design.

Proper drainage is critical for any road. Careful travelway drainage will avoid most pollution of nearby water courses. Road travelways are drained using sloped surfaces, culverts, dips, and rolled grades. Dips, open-topped culverts, and out-sloped roads are used for temporary and low

volume roads. Frequently used roads are usually crowned and have drainage ditches with pipe. Culverts are usually used to drain roads. The culverts must be at least 18 inches in diameter. Culverts must extend at least 2 feet beyond the toe of the fill. Drainage must be spaced frequently enough to remove water from the road surface before erosion begins. The frequency of drainage depends on the climate, soils, road location, and road grade. Drain spacing will be specified for all roads in the site-specific plan. Drainage must be in place before snowmelt runoff and the summer rainy season.

A properly located designed, and prepared crossing structure should be used at all water crossings. Water crossing sites will be designated in the site-specific plan. All equipment will cross only at those sites and no other. Roads that cross streams must cross at right angles. The crossings should be located at points of low bank slope and firm surfaces. Crossings should also have good lengths of similar channel above and below to avoid culvert alignment problems. Methods used for crossing channels include bridges, culverts, and fords. Fords can be constructed where water is shallow enough for vehicles to cross and the bottoms are solid and rocky. Fords should not be used in streams that have fisheries. Fords are generally used in intermittent streams.

Culverts are the most common stream crossings. Culverts must be designed to pass the entire 25-year flood flow with a headwater to depth ratio equal to 1. Culvert intakes and outlets require protection. Rock riprap or concrete is normally used. Streams with fisheries will require more stringent mitigation measures. Open bottom culverts or bridges will be required on steep channels. Bridges offer the least amount of obstruction to fish passage, the least use of fill within the water limits, and the least amount of alteration to bottom topography. Resting pools, cover, and bank protection should be improved for several hundred feet on either side of the culvert on steep streams. The Forest Fisheries Biologist will determine where these measures will be required. They will be specified in the site-specific plan. Temporary water crossings should be removed upon completion of the activity. Approaches to the stream crossing should have waterbars constructed and be revegetated.

Channelization of natural stream channels will be avoided if at all possible. Channel geometry relationships will be used to re-establish meanders, width/depth ratios, etc., where channelization is unavoidable.

Buffer strips will be required between all roads and sensitive areas. Roads must be surfaced where the minimum buffer strip width cannot be met.

2. Dam, Reservoir, and Shoreline. If sloughing or soil raveling along the shorelines is anticipated, the use of balloons or some other approved method to reduce wave action needs to be considered. Timber removal within the zone of inundation should be done using cable logging on slopes steeper than 40 percent in order to decrease the erosion potential along the shoreline.

3. Staging Areas and/or Borrow Site Location. All borrow areas will be approved by the USFS. They will not be allowed in drainages. Diversion ditches or dikes will be constructed to divert runoff around these areas. Drainage from these areas needs to be filtered before it reaches a water course. Buffer strips will be required as well as some type of sediment trap or basin. Oil and other fluids that are drained from equipment will not be disposed of on these sites. Periodic spraying of these areas by water will be required to control dust.

These areas will be revegetated and reclaimed as soon as all the material has been removed. Slopes need to be graded to less than the angle of repose and revegetated.

4. Diversion of Streams During Aggregate Excavation and Dam Construction. This is a most critical phase of the construction of a dam in terms of potential long- and short-term impacts to water quality, channel stability, and fisheries habitat. Location and design of the diversion channel will be approved by the Project Liaison. The diversion channel will be completed and lined (with appropriate rock or fabric) before the stream water is diverted into the channel. It will be designed to accommodate the 25-year flood event and constructed so as to dissipate the energy of the water sufficiently to prevent downstream channel instability and associated water quality violations.

There are many methods to divert water during dam construction, but perhaps the most effective is a permanent canal or culvert extending upstream and downstream of the dam fill. This conduit can then be filled with concrete when the dam is completed.

5. Recreation Facilities. Campgrounds and picnic grounds will not be located within the 100-year floodplain boundaries. These areas will be revegetated as soon as possible. This might include revegetation concurrently with construction activity. As one part of a campground is completed it can be revegetated. It is not a necessary to wait until the entire facility is constructed before revegetation is begun. Construction techniques for campgrounds should include retaining walls, hardened sites, drainage ditches, etc., when necessary and described elsewhere in this document. This is necessary to reduce soil loss and protect the site vegetation. These techniques would be described fully in the site design to be approved by the Responsible Official prior to construction.

Relocated or newly constructed trails will be built with a maximum grade of 15 percent and will be drained by water bars. The drainage spacing will be determined before construction of the trails is allowed. Switchback leadoff ditches should channel runoff to buffer areas where flow velocities can be reduced and sediment filtered out before reaching live water. Temporary sediment traps might be necessary.

6. Channel Maintenance Flows and Maximum Flow Limitations. Channel maintenance flows and maximum flow releases will be quantified by an approved method and stipulated in the land use authorization. A permanent recording stream gage will be installed to monitor reservoir inflow and outflow if an acceptable gage does not already exist. The proponent will

fund the construction, operation, and maintenance of the gages. If the results of long-term monitoring indicate that release flows are causing an undesirable effect on the channel downstream, additional mitigation will be required.

Options for additional mitigation include changing the channel to accommodate the release flows (riprap, manual vegetation removal, etc.) or altering release flows to mitigate the impact. Decisions concerning additional mitigation will be made by the agency issuing the land use authorization.

IV. MONITORING

The Forest Service must insure that activities occurring on NFS lands do not degrade water quality, channel stability, or the soil resource. The 1972 Water Pollution Control Act and the 1977 Clean Water Act have a comprehensive goal that includes maintaining the physical, chemical, and biological integrity of water. These acts also require that aquatic ecosystems will be returned to a state functionally equal to the original.

Forest Plans state that sediment yields will be maintained within threshold limits. The sediment threshold varies by stream size and type. It depends on the amount of flow that exists to transport sediment in the channel. Some streams in stable material are considered to be supply limited. In other words, the stream can transport more sediment than it is currently carrying. Other streams are said to be energy limited, that is, they currently transport all the sediment they are capable of transporting. Any additional sediment would be detrimental to the stream channel.

Forest Plan standards also state that soil productivity will be maintained or enhanced. Inherent soil productivity may be adversely impacted through proposed ground disturbing activities, which cause soil loss, soil displacement and soil compaction. Soil loss and soil displacement remove the fertile topsoil layer which is extremely important in plant establishment and growth. The displaced topsoil as well as exposed mineral soil is vulnerable to the erosive forces of wind and water. Soil that is susceptible to detachment through erosion is available for transport and delivery to streams as sediment.

Monitoring is necessary to determine the sediment threshold for each impacted stream as well as to ensure compliance during and after the construction activity. Monitoring is also necessary to determine if soil loss during and after construction is within tolerance limits for the given soil type. There are two types of monitoring required, one is long-term monitoring and the other is short-term monitoring. Both long-term and short-term monitoring are discussed below.

A. <u>Short-Term Monitoring</u>

Short-term monitoring will be carried out before, during, and after the construction phase. Short-term monitoring will determine sediment

threshold limits for impacted streams as well as assess the impacts of construction activities. Short-term monitoring of the soil resource will determine existing soil loss from project areas and assess the increase in soil loss from construction activities.

A monitoring plan of operation will be required as part of the site-specific plan. This plan will be approved by the USFS. The plan will specify the sampling locations, the type of data that will be collected, sampling frequency, and the type of analysis needed. The pre-project data that need to be collected include the following:

- Bedload and suspended sediment data during the snowmelt runoff period, the summer runoff period, and the baseflow period. Data also have to be collected during stormflow events.

- Streamflow during the rising, recession, base flow, and stormflow legs of the hydrograph.

- A pebble count at each monitoring site.

These data will be used to define the sediment yield threshold for each stream within the project area. Bedload and suspended sediment data will be collected in conjunction with streamflow data during the construction phase in order to ensure compliance with the threshold limit. The pre- and post-project data will be collected and analyzed by the proponent according to USFS specifications.

Soil monitoring will focus on the effectiveness of revegetation on disturbed areas. Generally, visual evidence of soil movement (rills, gullies, pedestaling around plants, and sediment catch in basins and traps) will trigger the need for more intensive efforts. The Responsible Official or Liaison will make the determination with the assistance of the Forest Soil Scientist. Modified Soil Loss Equation or other approved methods may be used to estimate actual soil loss.

B. Long-Term Monitoring

Long-term monitoring of any approved project will be an interdisciplinary venture to reduce duplication and conflicts. The aquatics, soils, and watershed team will develop monitoring plans together to determine the accuracy of the projected impacts and effectiveness of mitigation. Before monitoring begins, a long-term monitoring plan will be approved by the Forest Service and will be incorporated into the land use authorization. When monitoring plans are developed, the following questions will be addressed from a channel stability standpoint:

1. Are the dimensions of the active channel stable with flow over time?

2. Is sediment, both in size and volume, being distributed and transported in such a way as to prevent either aggradation or degradation?

3. Are the bed and banks stable?

4. Is there any change in channel capacity over time due to vegetative encroachment and sediment deposition?

Listed below are the general data needs that will be incorporated into monitoring plans:

1. A permanent record of stream cross-section dimensions and elevation, referenced to a bench mark elevation. A cross-section survey should be conducted annually.

2. Hydraulic geometry data to observe any shifts in these relationships.

3. Suspended sediment, bedload sediment including size distribution, and stream discharge data over a wide range of flows including:

   a. Rising limb of low elevation snowmelt runoff
   b. Recession limb of low elevation snowmelt runoff
   c. Rising limb of high elevation snowmelt runoff
   d. Recession limb of high elevation snowmelt runoff
   e. Bankfull
   f. Stormflow runoff

4. Channel materials size distribution (using the pebble count or similar method) on a permanent transect and proportionately sampling riffles and pools.

5. A monumented photo-point to document channel changes over time.

6. A record of flow diversions or importation as well as natural flows.

If during the course of monitoring unanticipated impacts are revealed, additional mitigation measures will be recommended.

V. LONG-TERM MAINTENANCE

To ensure reduction and elimination of environmental impacts over time, an agreement needs to be reached on the nature and extent of responsibilities the Proponent will assume regarding long-term maintenance of roads and facilities constructed as part of this project.

Regular maintenance and inspection of the roads, facilities, and permanent erosion control structures should be incorporated into the Operations Plans for the project. The party(s) responsible for long-term maintenance should be pre-determined before the project is initialized.